A STRATEGIC PLAN FOR EARTHQUAKE SAFETY IN UTAH

UTAH SEISMIC SAFETY COMMISSION

January 1995

PREFACE

This document is the result of many stages of planning and review, first by the Utah Earthquake Advisory Board and its four standing committees, and then by the Utah Seismic Safety Commission (USSC). The USSC was created in July 1994 by Utah House Bill 358 and was mandated to produce this document for the 1995 Utah Legislature. A draft of the document was completed in August 1994 and sent out for public comment during September 1994. Comments were solicited from state and federal government agencies, professional societies, the Utah League of Cities and Towns, the Utah Association of Counties, interested private individuals, and all groups listed as "responsible agencies" in the document. Written comments were received, carefully considered, and incorporated as feasible into this final report.

A Strategic Plan for Earthquake Safety in Utah emphatically is only a beginning, both in detail and in action. Implementing the strategic plan will be an evolutionary process that will adjust to changing priorities, new information, and broader community involvement. Utah has already made many significant steps toward earthquake safety and preparedness, but there is a long way to go. This document identifies needs and creates a framework to coordinate efforts and monitor progress. Hopefully we can use what was learned in the January 1994 Northridge, California, earthquake and other recent seismic disasters to prepare Utah before a large earthquake strikes here.

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EXECUTIVE SUMMARY

♦ *Introduction*

The mission of the Utah Seismic Safety Commission (USSC), building on work of its predecessor, the Utah Earthquake Advisory Board (UEAB), is to develop a strategic plan for earthquake safety in order to save lives, prevent injuries, protect property and the environment, and reduce social and economic disruption from earthquakes. This document was developed through a review and planning process undertaken by the UEAB and contains a list of recommended "strategies" to reduce losses from earthquakes. The document has been completed and adopted by the Utah Seismic Safety Commission as a strategic plan for presentation to the 1995 Utah Legislature.

The main points this document attempts to make are the following:

1. There is a real and serious danger of both life-threatening and damaging earthquakes in Utah in our lifetimes.

2. We as individuals and collectively can take significant actions now to reduce the loss of life, property damage, and long-term economic impact in the future.

3. Implementing an earthquake-safety plan for Utah is a long-term process.

4. Strategies to safeguard lives and property from earthquakes must be sensitive to financial and regulatory burdens. Many actions can be taken now without great expense that will make Utah safer tomorrow.

We believe government has a fundamental responsibility to protect the health, safety, and welfare of its citizens. With respect to earthquake safety, this involves five basic actions: (1) improving our geotechnical understanding of earthquakes and earthquake hazards, (2) improving development and construction practices, (3) educating the public, (4) disaster-response planning, and (5) post-earthquake recovery planning. These actions and the recommended strategies in this document are consistent with Governor Leavitt's Key Objectives and with the Utah Legislature's strategic plan, *Utah Tomorrow*. The individual strategies have been placed in a format consistent with state planning guidelines.

Efforts to promote public policy for earthquake safety in Utah began nearly two decades ago with the Utah Seismic Safety Advisory Council (1977-1981), followed by the Earthquake Task Force of the Utah Advisory Council on Intergovernmental Affairs (1989-1991) and later the UEAB (1991-1994). Responsibility has now passed to the USSC.

♦ *The Earthquake Threat in Utah*

Utah has experienced damaging earthquakes in the past, and geologic evidence indicates that earthquakes larger than any experienced locally in historical time are likely in the future. Large earthquakes are possible anywhere in Utah, but they are most likely in a "seismic belt" about 100 miles wide extending north-south along the Wasatch Front and through Richfield to Cedar City and St. George.

Earthquakes produce a variety of geologic hazards that threaten life and property. These hazards include ground shaking, surface fault rupture, regional subsidence, liquefaction and related ground failure, landslides, rock falls, and various types of flooding. Earthquake hazards are greatest in the Wasatch Front area because of the greater earthquake probability and because of extensive areas where geologic conditions pose the potential for damaging, earthquake-induced effects. The probability of large earthquakes appears to be slightly lower in southwestern Utah, and geologic conditions there are not as prone to aggravate earthquake effects. In general, earthquake probabilities and hazards are lower in eastern and western Utah outside the main seismic belt.

We must prepare for earthquakes because: (1) Utah is a seismically active region, (2) our population is concentrated in the areas of greatest hazard, and (3) many of our older buildings and lifelines have low earthquake resistance. We have been lucky so far to experience only moderate-sized earthquakes, of which the majority have originated in areas of low population; we cannot expect this luck to last.

♦ *Strategies for Earthquake Safety*

The following pages list the main objectives and strategies for earthquake safety. The list of strategies, which is not in order of priority, is not intended to be exhaustive. Work will continue to develop consensus and to set priorities for action. Also listed in the following pages are the planned outputs (for example, products, plans, and assessments) and desired outcomes, in terms of increased earthquake safety, for each strategy.

Summary of Strategies

Objective 1: Increase earthquake awareness and education.

Strategy	Output	Outcome
1.1 Inform citizens about earthquake hazards and risks.	Information and training targeted to meet individual or collective needs.	All citizens are better able to prepare for and respond to an earthquake.
1.2 Incorporate earthquake education in school curricula.	A multi-level curriculum for earthquake education in all public schools.	All students are provided with earthquake science and safety training as a part of their regular education.
1.3 Disclose geologic hazards in real-estate transactions.	Homebuyers are made aware of geologic hazards at a property prior to purchase.	Homebuyers are more informed in their decisions.

Objective 2: Improve emergency response and recovery.

Strategy	Output	Outcome
2.1 Establish community emergency response teams (CERTs) statewide.	Trained volunteer community emergency response teams exist statewide.	Reduce life, property, and environmental loss by providing more immediate response in a disaster.
2.2 Develop effective exercise and training programs for hospitals.	All hospital staff are trained for earthquake emergency response including implementing a standardized triage system.	Hospitals are prepared for earthquake response.
2.3 Enhance communication capabilities for emergency responders.	Develop a communication system that will allow for the use of new technologies and provide the capability of expansion during peak disaster use.	Emergency response capability will be enhanced because the new communication system will allow for the interoperability of agencies to meet the requirements of multi-agency response.
2.4 Enhance the integrated emergency management system statewide.	An intergrated emergency management system at all levels of government and the private sector to protect life, health, property, and the environment.	All jurisdictions and agencies can more fully utilize their resources to respond to any type of a disaster, including earthquakes.

Objective 3: Improve the seismic safety of buildings and infrastrucure.

Strategy	Output	Outcome
3.1 Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.	Competent plan reviews are completed for new construction.	Help ensure that new buildings are being designed safely by competent professionals to withstand seismic forces.

3.2 Enforce the state amendment to the Uniform Building Code which requires building owners to install roof anchors and parapet bracing when reroofing their buildings.	Copies of the amendment are distributed to building officials, architects, and engineers through the media and professional societies, and education programs are conducted.	A gradual decrease in the seismic hazard posed by existing unreinforced masonry buildings.
3.3 Improve the post-earthquake operational status of essential service buildings.	All essential government services buildings are identified. Buildings constructed before 1976 are retrofitted or relocated as needed, to meet standards that will allow them to remain operational after an earthquake.	The ability to provide unimpeded disaster relief services.
3.4 Reduce structural hazards of government-owned buildings.	Government-owned buildings structurally modified to better withstand earthquakes.	A safer environment to conduct government business.
3.5 Mitigate nonstructural hazards in government-owned and -leased buildings.	Assess hazards in government-owned buildings and upgrade as necessary.	A safer and operational working environment for government agencies following an earthquake.
3.6 Improve safety of older public school buildings.	Identify and reduce structural and non-structural seismic hazards in all pre-1976 public school facilities.	Safer facilities for students and teachers, as well as buildings usable in an emergency.
3.7 Improve safety and operational ability of older hospital buildings.	Assess earthquake vulnerability of all hospitals and upgrade the structures to better survive an earthquake.	Safe structures that will provide a more secure environment for patients and staff and improved ability to survive an earthquake and provide disaster relief.
3.8 Improve safety of older high-occupancy buildings (250 persons or more) to be structurally competent to withstand moderate to large earthquakes.	Assess seismic vulnerability of all older high-occupancy structures and retrofit or disclose building condition upon resale.	Prevent collapse in the event of an earthquake, thus reducing life loss, property loss, potential secondary effects, and reconstruction costs.
3.9 Improve the seismic safety of older homes.	Create and distribute maps of seismic-hazard areas and upgrade information packets, procedural manuals, standards, and requirements to all affected home owners, all real-estate agents, building contractors, and lending institutions. Establish funding sources and incentives to encourage seismic-safety retrofitting.	Improved safety and lower repair costs in the event of an earthquake.
3.10 Improve safety of mobile homes.	Seismically brace all new mobile homes; retrofit inadequately braced existing mobile homes at time of resale. Create and implement incentive packages to encourage mobile home owners to retrofit existing installations.	Increased safety for occupants, reduced amounts of utility rupture and associated hazards and repair costs.

3.11 Prevent loss of historic buildings.	Vulnerability assessments and mitigation completed on buildings on the National Historic Register.	The preservation of historic buildings and their associated heritage in the event of an earthquake.
3.12 Improve lifeline survivability in the event of an earthquake.	Assess and mitigate earthquake hazards on all lifelines.	Functional or easily/rapidly repairable lifelines after a earthquake.
3.13 Improve earthquake performance of water and waste-water systems.	Establish appropriate and practical uniform safety and emergency-response plans for all water and waste-water systems.	Improved safety, performance, and reliability of water and waste-water systems.

Objective 4: Improve essential geoscience information.

Strategy	Output	Outcome
4.1 Reduce earthquake losses by mapping and identifying geologic hazards.	Hazard maps for all earthquake-prone urban areas.	Development and management are safer, more reasoned, and more cost-effective.
4.2 Perform geologic-hazards investigations for critical public facilities.	Geologic-hazards investigations are performed for all new critical public facilities.	Critical facilities will not be sited in hazardous areas and, in the event of a natural disaster, facilities that are needed for emergency response will remain intact.
4.3 Make land use compatible, through local government ordinances, with known hazards.	Local governments are encouraged or required to adopt geologic-hazards ordinances as needed.	Land use is safer and consistent with identified geologic hazards.
4.4 Ensure design professionals and building officials are kept current on relevant geoscience information.	Periodic meetings of geoscientists and engineers to discuss implications of geoscience information to building safety.	Up-to-date, reliable geoscience information is used to guide the safe and economical earthquake-resistant design of new buildings.
4.5 Determine appropriate seismic criteria and procedures for evaluating performance of existing dams.	Guidelines for seismic safety assessments of existing dams.	Uniform, state-of-the-art assessments of seismic safety of dams.
4.6 Reduce earthquake-induced liquefaction risk to highway structures.	Identify all hazardous bridges; generate a plan to reduce hazards.	Highway bridges are safer in the event of earthquake-induced liquefaction.
4.7 Determine appropriate seismic design coefficients for highway bridges.	Calculate and incorporate new seismic design coefficients in design work for new bridges associated with the widening of I-15.	(1) Ensure that the best available information is used for the safe and economical design of the new bridges. (2) Prevent the need for retrofit of the bridges in the near future. (3) Reduce bridge damage in an earthquake.

4.8 Develop incrementally a strong-motion program.	Deploy at least 108 accelerographs in the seismic regions of the state to record strong ground shaking.	The hazard of strong ground shaking from local earthquakes is better quantified so it can be correctly incorporated into safe, cost-effective design of buildings and other structures. Key information can also be rapidly available for crisis management.
4.9 Develop a statewide, real-time earthquake monitoring system.	(1) Increased number of seismically vulnerable counties and cities in Utah for which continuous and accurate instrumental earthquake data are available. (2) Rapid emergency alert, within minutes after the occurrence of an earthquake in the Utah region, to state-agency officials, emergency managers, and the general public.	Collect and distribute data needed: (1) for more cost-effective earthquake engineering, (2) for more rapid and effective emergency response, (3) to reliably quantify earthquake dangers, and (4) to improve scientific understanding of local earthquake behavior, in order to better mitigate effects.
4.10 Monitor faults using Global Positioning System (GPS) measurements.	Regular monitoring of a network of GPS benchmarks.	Strain buildup and ground deformation associated with faults are understood on a very detailed level, allowing more accurate estimation of the likelihood of large earthquakes and accompanying hazards.

Objective 5: Assess earthquake risk.

Strategy	Output	Outcome
5.1 Update estimates of direct losses expectable from earthquakes.	Comprehensive studies to estimate the potential loss of life, number of injuries, and damage to structures and lifelines from earthquakes of various magnitudes and locations.	Earthquakes are placed in a proper policy perspective based on credible projections of losses and societal impacts; emergency planning is improved; and long-term hazard-reduction activities are prioritized.
5.2 Evaluate the indirect losses associated with earthquakes.	A study assessing the indirect economic losses from earthquakes including: wage and job loss, rebuilding cost, impacts on insurance and financial institutions, and costs of business interruption and failure.	Identification of indirect economic impacts, resulting in increased preparedness, more rapid recovery, and wise resource allocation.
5.3 Conduct lifeline collocation vulnerability studies.	All lifeline collocation sites in UBC seismic zone 3 are identified; a plan is developed for each one.	During an earthquake emergency, damaged lifelines in one area will not cripple each other.

INTRODUCTION

♦ *Mission*

The impacts of earthquakes are well known. This knowledge has come at great cost in lives and property. We must take advantage of this knowledge to adopt policies and take actions to save lives and prevent injuries, protect property and the environment, and reduce social and economic disruption from earthquakes in Utah. With the ultimate goal of making Utah a safer place to live, the mission of the Utah Seismic Safety Commission (USSC), as for its predecessor, the Utah Earthquake Advisory Board (UEAB), is to function as a medium for state and local governments, the private sector, and the public to advance earthquake-related issues by developing, researching, and recommending seismic policies and approaches aimed at reducing Utah's earthquake hazards and managing Utah's earthquake risk. The USSC was given the charge to:

- ❑ Review earthquake-related hazards and risks in Utah.
- ❑ Prepare recommendations to identify and mitigate these hazards and risks.
- ❑ Prioritize recommendations for adoption as policy or loss-reduction strategies.
- ❑ Act as a source of information for earthquake safety and promote earthquake loss-reduction measures.
- ❑ Prepare a strategic seismic safety planning document for the 1995 General Legislative session.
- ❑ Update the strategic planning document and other supporting studies or reports.

To achieve part of its mission, the USSC has completed this document prepared in draft form by the UEAB. The main points that the USSC and this document are attempting to make are the following:

1. There is a real and serious danger of both life-threatening and damaging earthquakes in Utah in our lifetimes.

2. We as individuals and collectively can take significant actions to reduce the loss of life, property damage, and long-term economic impact in the future.

3. Implementing an earthquake-safety plan for Utah is a long-term process.

4. Strategies to safeguard lives and property from earthquakes must be sensitive to financial and regulatory burdens. Many actions can be taken now, without great expense that will make Utah safer tomorrow.

♦ *Government Responsibility*

We believe government has a fundamental responsibility to protect the health, safety, and welfare of its citizens. The government's role in improving earthquake safety is to foster, encourage, and, where necessary, require individual and collective action to deal responsibly with the earthquake threat. Reducing our vulnerability to earthquakes requires five types of actions: (1) improving our geotechnical understanding of earthquakes and earthquake hazards, (2) improving development and construction practices, (3) educating the public concerning earthquake hazards and how to respond during a hazardous event, (4) disaster-response planning, and (5) post-earthquake recovery planning. These actions necessarily involve an understanding of what will be effective in reducing risk and an appreciation of the willingness and ability of the people involved to take action.

Government, academic, and private-sector scientists and engineers must work together to understand the earthquake threat to help determine which loss-reduction strategies are appropriate and cost-effective. Improvement of development and construction practices is primarily the responsibility of state, county, and municipal government agencies through adoption and enforcement of building codes, subdivision zoning, and retrofit ordinances. Public education is an ongoing process requiring coordination and cooperation among local school districts, state agencies, and universities to reach all citizens. Government agencies must develop disaster-response plans to identify: (1) the types of decisions that are likely to be needed when the expected earthquake event occurs, (2) who will make the decisions, and (3) how the decisions will be transmitted to the public and emergency-response personnel for implementation. Recovery plans are also needed to anticipate and meet the needs of communities as the post-earthquake recovery period unfolds over a period that may be as long as 5 to 20 years. These plans will help ensure a quick return to cultural and economic viability following an earthquake.

♦ *Governor's Objectives*

For effective strategic planning, within the realm of state government, plans should be developed in harmony with a statewide vision. The cornerstone of Governor Leavitt's planning agenda is a set of overall policy goals known as the "**Five Key Objectives**." These objectives address issues critical to elevating Utah State Government to a new level of performance. They are:

1. Providing a world-class education.
2. Creating quality jobs and business climate.
3. Improving government.
4. Enhancing the quality of life for all Utahns.
5. Fostering self-reliance.

The strategies proposed in this document are consistent with Governor Leavitt's Key Objectives. They are also consistent with—and indeed many are already part of—the Utah State Legislature's strategic plan, *Utah Tomorrow.*

First, dealing with Utah's earthquake threat relies on earthquake science and engineering, much of it within Utah's system of higher education, involving the development and application of modern technologies in a world-class way.

Second, a healthy business climate in Utah depends on essential infrastructure—including the means to deal with a real and serious earthquake threat. As emphasized by a 1989 blue-ribbon panel (convened to review earthquake instrumentation in Utah), "Potential earnings will come...from increased willingness on the part of risk-conscious investors to fund large projects in Utah once the earthquake threat and the means to cope with it are better understood." A decision by state policy-makers to implement a strategic plan for dealing with Utah's earthquake dangers will favorably impress sophisticated risk managers, who increasingly will be involved, for example, in the siting of new industries or in decisions to fund private economic development.

Third, this plan provides a means to improve government by increasing awareness of the earthquake threat and promoting responsible actions to reduce risks. The threat is far-reaching, requiring a coordinated effort by all levels of government - federal, state, and local.

Fourth, the strategies proposed in this plan are fundamental for ensuring quality of life in the form of safety for all Utahns in their homes, schools, workplaces, and neighborhoods.

Fifth, self-reliance involves education, which inherently involves information and public instruction, to deal with the complexities of modern life. One complexity is that earthquakes pose the greatest natural threat to life and property in Utah. These strategies are intended to help Utahns become progressively self-reliant in avoiding major loss of life and property in earthquakes.

♦ *History of Seismic Advisory Committees in Utah*

In 1976, the United States Geological Survey (USGS) published a study of the likelihood of and projected losses from major earthquakes in Utah. This study reported that a moderate to large earthquake was likely to strike the Salt Lake City area within the next 100 years with serious repercussions. The USGS considered "seismicity, geological history, population density, and distribution and physical status of structural and lifeline installations throughout the region." The USGS report appeared in the aftermath of a magnitude 6.0 earthquake in March 1975 in Pocatello Valley on the Idaho-Utah border. This earthquake was felt throughout the Salt Lake Valley and the northern part of Utah and damaged several buildings in Salt Lake County. The combined effect of the 1975 earthquake and the 1976 USGS report was to awaken political support for earthquake action among public officials representing Utah's urban areas.

Utah Seismic Safety Advisory Council, 1977-1981

State Representative Genevieve Atwood sponsored a bill in the 1977 Utah Legislature to create an earthquake advisory council to attend to seismic safety issues. The Utah Seismic Safety Advisory Council (USSAC) (see appendix) was created and became the first successful effort to shape public policy for reducing earthquake risk in Utah. The USSAC mission was to "provide recommendations for a consistent policy framework for seismic safety in Utah, to recommend programs to reduce earthquake hazards, and suggest goals and priorities..." Their charge was to recommend a consistent and comprehensive public policy plan for earthquake risk reduction in Utah. Even though USSAC products were highly commended, no agency or group was given responsibility to follow through on the recommendations. Very few of the recommendations were implemented and none of the suggested legislation became law.

The USSAC, nonetheless, made a significant difference in earthquake risk reduction in Utah by:

- Linking several of the isolated scientists and earthquake-safety activists into a network.
- Focusing attention on earthquake hazards.
- Writing a series of reports that documented the status quo of earthquake preparedness and provided a framework for action.
- Bringing together local leaders with national experts.
- Providing visibility for all individuals and agencies who wanted to contribute to earthquake-hazard reduction.
- Providing an umbrella of political legitimacy to engineering, political, scientific, and other professional groups who lobbied their membership for increased acceptance of state-of-the-art techniques.
- Providing a supportive network that lasted beyond the lifetime of the organizations.

The USSAC conducted or commissioned numerous studies, sponsored meetings, issued reports, and in other similar ways dealt with the earthquake threat in Utah.

1981-1991

After the USSAC was dissolved in 1981 under the "sunset" provision of its enacting law, the role of coordinating a state earthquake program effectively passed to informal cooperative efforts among the Utah Geological Survey (UGS), the Utah Division of Comprehensive Emergency Management (CEM), and the University of Utah Seismograph Stations (UUSS). Federal attention to Utah's earthquake threat greatly increased from 1983 to 1988 as part of a special five-year focus on earthquake hazards and risk in the Wasatch Front region by the U.S. Geological Survey under the National Earthquake Hazards Reduction Program. As a result of the five-year program, earth scientists and engineers amassed a large body of technical information and reached fundamental agreement about the seriousness, extent, and nature of Utah's earthquake dangers. Despite a greatly-heightened public awareness of Utah's earthquake threat, numerous attempts to motivate state governmental action on earthquake issues were mostly unsuccessful. From 1989-1991, most of these efforts were coordinated through the Earthquake Task Force of the Utah Advisory Council on Intergovernmental Relations (UACIR) (see appendix). The UACIR's activities culminated in late 1990 when the Earthquake Task Force presented a list of critical needs for 1991 legislation to improve earthquake safety. As a result, six bills and one resolution which in some way dealt with earthquake safety were introduced into the 1991 Legislature. All failed (through inaction rather than defeat), but the debate over the bills further increased awareness and gained support from many key legislators.

Utah Earthquake Advisory Board (UEAB), 1991-1994

In 1991, the Utah Earthquake Advisory Board (UEAB) was formed at the instigation of state officials and was funded through CEM by a supplemental grant from the Federal Emergency Management Agency (FEMA). Approval was gained to create the Board as an advisory group within the executive branch of state government, placing it under the Governor's Disaster Emergency Advisory Council. Under the terms of the Board's charter, Board members were chosen from leaders in their fields of expertise such as seismology, geology, structural engineering, geotechnical engineering, architecture, public policy, and emergency management. The makeup of the Board included members representing state agencies, local government, professional organizations, and the private sector (see appendix).

The mission of the UEAB was to advance earthquake-related issues by developing, researching, and recommending seismic policies and providing a long-term strategic planning document to reduce Utah's earthquake hazards through managing the state's earthquake risk. With completion of the draft of this document, the UEAB achieved a major part of its mission and turned its responsibilities over to the Utah Seismic Safety Commission, effective July 1, 1994.

Utah Seismic Safety Commission, 1994 to present

State Representative Kim Burningham introduced legislation in the 1994 Utah Legislature to establish a commission to study and advance earthquake safety in Utah. HB 358 passed, establishing the Utah Seismic Safety Commission (USSC) and designating the Utah Division of Comprehensive Emergency Management and the Utah Geological Survey to provide staff support. The make-up of the USSC is similar to the UEAB but includes representatives from the Utah Senate and House of Representatives (see appendix). The USSC was charged with preparing a strategic planning document for the 1995 Utah Legislature. With completion of this document, the duties of the USSC shift to facilitating implementation of the strategic plan and keeping it up-to-date.

♦ *Acknowlegements*

The USSC gratefully acknowledges the help of the UEAB and its standing committees, identified in the appendix, and UEAB staff support by: Bob Carey, Jim Tingey, Caryn Johnson, Nancy Barr, John Rokich, Jeanne Andersen, and Judy Watanabe of CEM; Gary Christenson, Noah Snyder, and Janine Jarva of the UGS; and Sue Nava of the UUSS. These staff, along with UGS staff Barry Solomon and Don Adams, helped prepare this report.

THE EARTHQUAKE THREAT IN UTAH

Earthquakes can cause injury and death, major economic loss, and social disruption. They occur with no warning. A recent, disturbing example was the magnitude 6.7 Northridge, California, earthquake of January 17, 1994, in the densely populated Los Angeles metropolitan area. The earthquake killed 61 people, injured 7,300, made 21,000 homes and apartments uninhabitable, and caused an estimated $20 billion in damage.

Utah has also experienced damaging earthquakes and has the potential for earthquakes larger than the recent Northridge shock. Although no large earthquake has occurred in Utah since settlement in 1847, geologic studies indicate that earthquakes of magnitude 7.0 to 7.5 have occurred repeatedly in Utah in prehistoric time. Along the populous Wasatch Front such earthquakes occur on the Wasatch fault, on average, once every 400 years. Some experts believe that the last occurred about 400 years ago.

♦ *What Is An Earthquake?*

An earthquake is the abrupt rapid shaking of the earth caused by sudden slippage of rocks deep beneath the earth's surface. The rocks slip when they can no longer withstand accumulated forces. The zone of weakness along which the rocks slip is called a fault. Shaking is caused by seismic waves travelling outward from the fault break (figure 1).

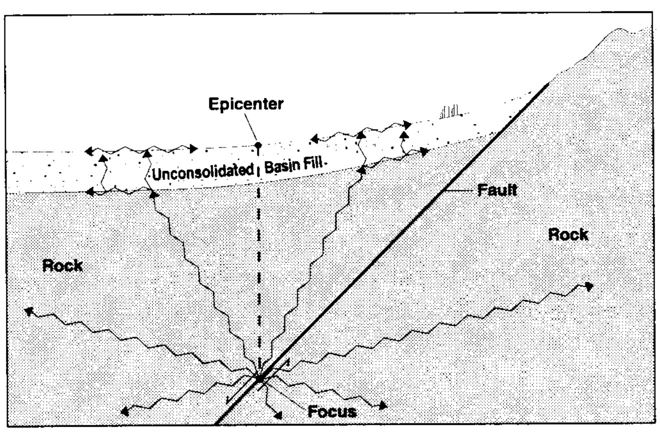

Figure 1. Generation of seismic waves by fault rupture in an earthquake as shown in this cut-away cross section. The focus is the place on the fault where the rupture begins. The point on the surface directly above the focus in the epicenter.

The most commonly used way to measure earthquake size has been the Richter scale, which measures the magnitude of earthquakes based on the amount of ground shaking recorded on a seismograph. The scale has no upper or lower bounds. Each 1-unit increase of the scale represents a 10-fold increase in the amplitude of ground displacement at any site. For example, a magnitude 6 earthquake causes 10 times greater ground displacement at the same distance than does a magnitude 5 earthquake. More importantly, each 1-unit increase represents a 30-fold increase in energy release. Thus a magnitude 6 earthquake is 30 times more powerful than a magnitude 5 earthquake. A magnitude 7 earthquake is nearly 1000 times more powerful than a magnitude 5 earthquake. An earthquake must generally be at least magnitude 2 to be felt by people, and about magnitude 5.5 before significant damage occurs. Seismologists are now using "moment magnitudes" to measure earthquakes, which extends the original Richter magnitudes to greater distances and to larger earthquakes.

♦ *Where Will Earthquakes Occur?*

Earthquakes can occur anywhere in Utah...

Hundreds of small earthquakes are recorded each year in the Utah region (figure 2.) Moderate, potentially damaging earthquakes (magnitude 5.5 to 6.5) occur every several years on average. An earthquake of magnitude 5.8 occurred near St. George on September 2, 1992. The most damaging effect of that shock was a destructive landslide in the town of Springdale, about 28 miles from the earthquake epicenter (figure 3.) Larger earthquakes occur less frequently than smaller earthquakes, but the potential for large earthquakes (magnitude 6.5 to 7.5) exists over much of Utah. Such an earthquake in the Salt Lake City area could cause up to $8.5 billion in damage to private buildings and homes alone, not including damage to other kinds of structures and facilities, and other indirect financial losses. Estimates of potential life-loss and injury made in 1976, now out of date and probably low, indicate that under the worst conditions (but assuming no dam failures), 2,300 people could die and 9,000 suffer injuries requiring medical treatment. As many as 30,000 people could be homeless and require temporary shelter.

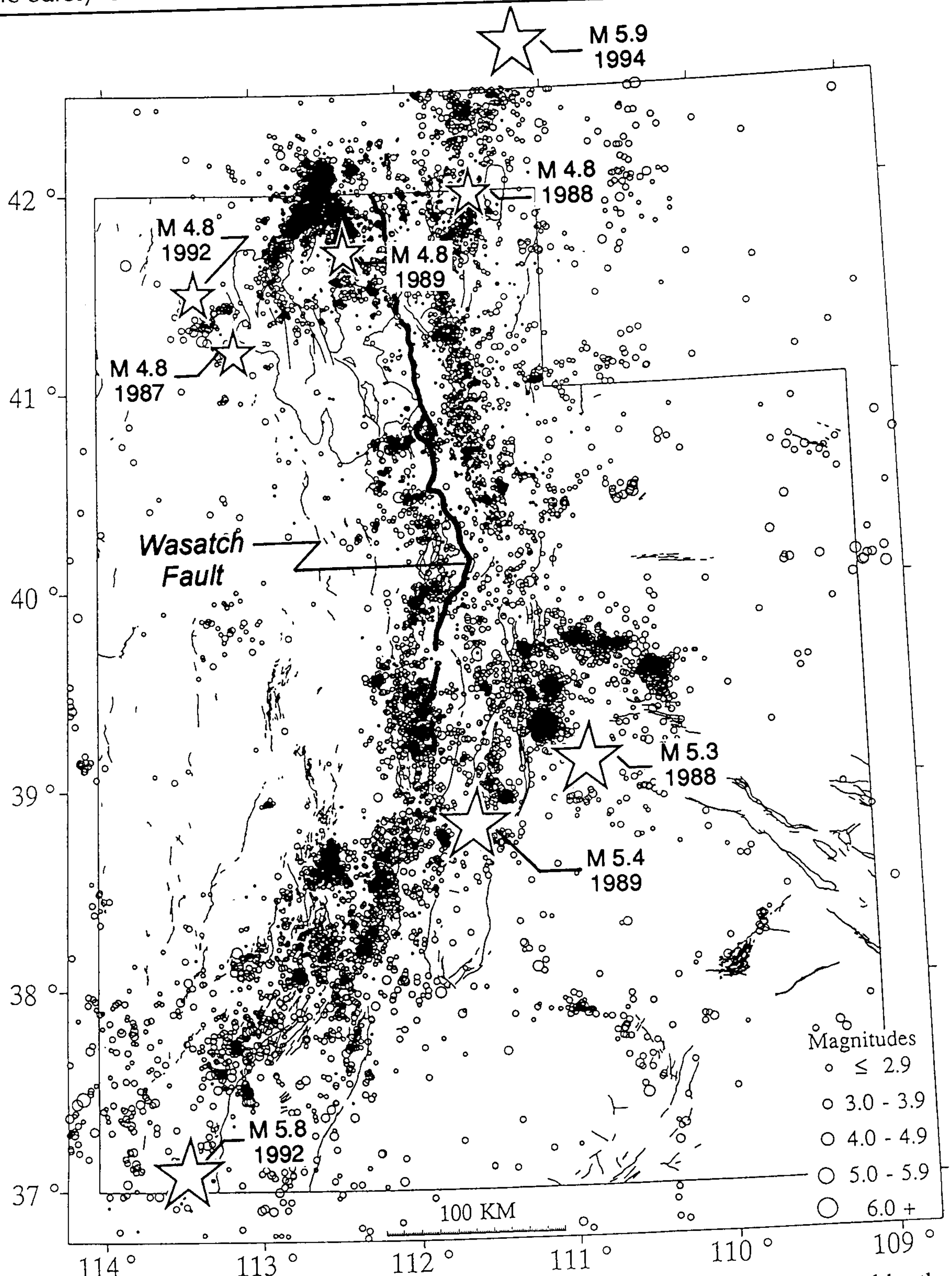

Figure 2. Map of Utah region showing the epicenters of more than 16,000 earthquakes located by the University of Utah Seismograph Stations from 1962 though 1993. Earthquakes of magnitude 4.8 and larger since 1987 shown as stars. The base map showing geologically young faults was compiled by the Utah Geological Survey.

Figure 3. House destroyed by landsliding in Springdale triggered by the magnitude 5.8 St. George earthquake of September 2, 1992. Photo by Bill D. Black, Utah Geological Survey.

...but there is a greater potential in certain areas.

The Intermountain Seismic Belt, which passes through Utah, is a broad zone more than a hundred miles wide where the frequency of earthquakes and the potential for moderate to large earthquakes is greatest. In Utah, the seismic belt passes through the north-central part of the state along the Wasatch Front and then turns southwestward through Richfield and Cedar City (figure 4.) Utah's part of the seismic belt has historically been characterized by small to moderate earthquakes, but there is clear geologic evidence of large prehistoric earthquakes in the magnitude 7 range. The earthquake probability is lower both east and west of the main seismic belt. These areas are characterized by less frequent earthquakes of all magnitudes, but they are not earthquake free.

♦ *Geologic Hazards Caused By Earthquakes*

Earthquakes cause a wide variety of life-threatening and potentially damaging geologic hazards in Utah. The principal earthquake hazards are ground shaking, surface fault rupture, regional subsidence, liquefaction and related ground failure, slope failure, and various types of flooding (table 1). Ground shaking affects large areas and, for a given earthquake, is generally strongest near the epicenter. In the 1994 Northridge, California, earthquake ground shaking was responsible for 98 percent of the estimated \$5.9 billion in direct damages. Surface fault rupture usually occurs only in earthquakes of about magnitude 6.5 and larger. This ground rupture may

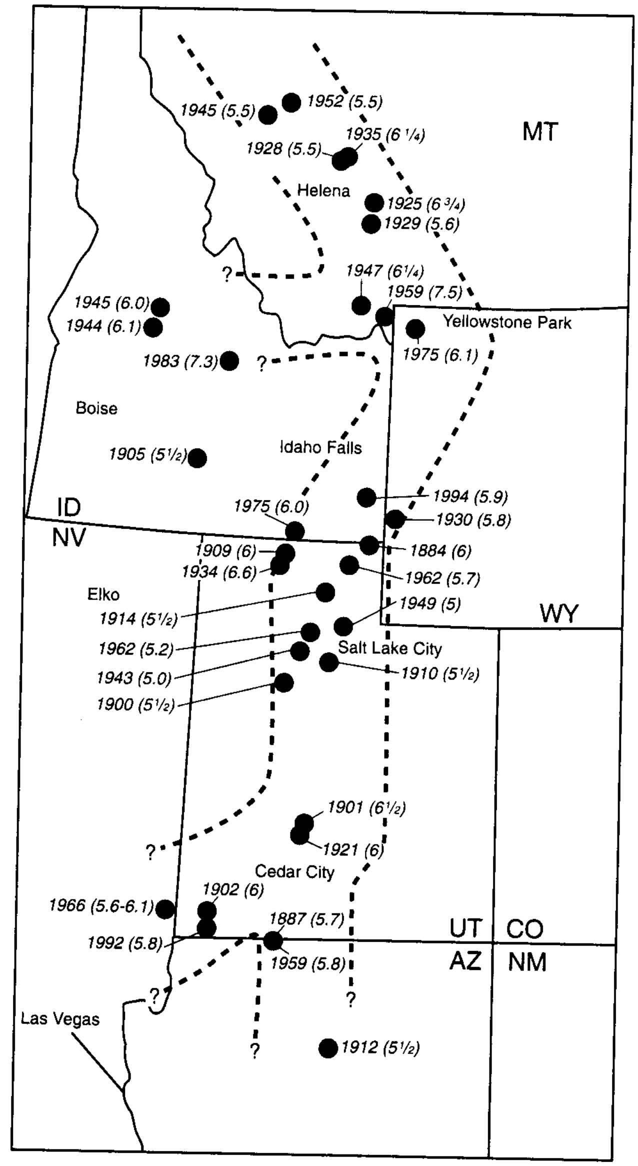

Figure 4. The Intermountain Seismic Belt (area between dashed lines) and the epicenters of historical earthquakes of magnitude 5 and greater (large dots). Year and magnitude are labeled for each earthquake. Modified from Arabasz, W.J., Pechmann, J.C., and Brown, E.D., 1992, Observational seismology and the evaluation of earthquake hazards and risk in the Wasatch Front area, *in* Gori, P.L., and Hays, W.W., editors, Assessment of regional earthquake hazards and risk along the Wastch Front, Utah: U.S. Geological Survey Professional Paper 1500-D, p. D6.

Table 1. Principal earthquake hazards, expected effects and hazard-reduction techniques.

Hazard	Effects	Hazard-Reduction Techniques
Ground Shaking	Damage or collapse of structures	Make structures seismically resistant, secure heavy objects
Surface Fault Rupture	Tilting and ground displacement	Set structures back from fault
Regional Subsidence	Ground tilting; flooding and loss of head in gravity-flow structures	Create buffer zones, build dikes, restrict basements, design tolerance for tilting
Liquefaction	Differential settlement, ground cracking, subsidence, downslope movement of earth material	Treat soil, design structural solutions
Rock Fall	Damage due to impact	Avoid hazard, remove or stabilize rock, protect structures
Landslides	Damage to structures, loss of foundation support	Avoid hazard, remove material, stabilize slopes
Seiches	Inundation, drowning, erosion	Avoid hazard, flood-proof and/or strengthen structures, elevate buildings

affect a zone many hundreds of feet wide along the surface trace of the fault that caused the earthquake. Regional subsidence and tilting of the downdropped block during a large surface-faulting earthquake extends miles from the fault, affecting a much larger area than surface faulting. Liquefaction (the temporary transformation of a cohesionless soil into a fluid mass accompanying earthquake ground shaking) is expected in areas of shallow ground water and sandy soils such as in the centers of basins and along streams. Liquefaction can result in various types of ground failure. Rock falls are the most common type of slope failure during earthquakes, but failures of many types may be expected in any hilly or mountainous area where earthquakes occur. Earthquakes may cause changes in water levels in wells and other permanent changes in hydrologic conditions. Flooding may result from water-line or canal breaks, stream diversions, increased ground-water discharge, seiches (waves on the surface of water in a lake, commonly initiated by an earthquake), and failures of dikes and dams. Ground subsidence on the valley side of the Wasatch fault could shift the shoreline of Great Salt Lake or Utah Lake eastward, resulting in inundation of neighboring areas.

♦ *In the Wasatch Front region*

Along the main seismic belt in Utah, earthquake hazards are greatest along the Wasatch Front because: (1) the Wasatch fault, which bounds the west edge of the Wasatch Range, has been the most frequent source of large earthquakes in Utah, (2) deep valley-basins filled with soft soils amplify ground shaking, (3) extensive areas are underlain by shallow ground water and liquefiable soils, and (4) Great Salt Lake, Utah Lake, and many reservoirs increase flood hazards associated with earthquakes. The largest historical earthquake in Utah was a magnitude 6.6 shock in 1934 that originated in Hansel

Valley, north of Great Salt Lake. The most damaging earthquake in Utah's history also occurred in the general Wasatch Front region -- a magnitude 5.7 shock near Richmond, Cache Valley, in 1962 (figure 5.)

♦ *In southern Utah*

Historical earthquake activity has been relatively high along the Intermountain Seismic Belt in southern Utah. But geologic evidence for recurrent, large surface-faulting earthquakes in southwestern Utah during the past 30,000 years is not as strong as in north-central Utah, where the Wasatch fault and other faults appear to be more active than faults to the south. The second largest historical earthquake in Utah was along the main seismic belt in southern Utah -- the 1901 earthquake near Richfield of estimated magnitude 6.5. One of the most prominent faults in southern Utah, the Hurricane fault, was the probable source of the 1992 St. George earthquake.

Shallow ground water is present in valley bottoms in southern Utah, but much less extensively than in northern Utah and thus the liquefaction hazard is lower. Areas of thick basin fill and soft soils are also less common in southern Utah, and therefore hazards due to amplified ground shaking are less. Because southern Utah has fewer large surface-water impoundments and natural lakes, the danger of earthquake-induced flooding is lower.

Figure 5. House damaged in Richmond during the 1962 earthquake, magnitude 5.7, the most damaging earthquake in Utah's history. Photo by Ariel D. Benson, Richmond, Utah.

♦ *In eastern Utah*

In eastern Utah, east of the main seismic belt, the earthquake probability and hazard is relatively low, but moderate-sized, potentially damaging earthquakes can occur. The largest historical earthquake in this region was the 1988 San Rafael Swell earthquake of magnitude 5.3. In Carbon and Emery Counties, extensive mining-induced seismicity results from stress redistribution caused by underground coal mining, posing a danger chiefly to mine operations. Shallow ground water is uncommon in eastern Utah, found chiefly in stream bottoms, so liquefaction is a minor hazard. Bedrock is exposed or shallow over much of the area so amplified ground shaking is unlikely, although seismic waves will travel farther and dissipate less quickly than in western Utah. Rock falls may be the most significant hazard in eastern Utah because they can be locally generated by earthquakes as small as magnitude 4, and many potentially unstable cliffs are present in the area.

♦ *In western Utah*

Earthquake hazards are also relatively low in western Utah west of the main seismic belt. However, amplified ground shaking is a hazard in valleys with deep sediments, liquefaction hazards are present in the northern valleys, and surface-faulting hazards are present along range-front faults. Slope-failure hazards are present but not extensive in the various mountain ranges, but these hazards increase to the east along the western fringe of the main seismic belt.

♦ *Why We Should Prepare For A Major Earthquake*

- ❑ Utah is a seismically active region.
- ❑ Utah's population is concentrated in the area of greatest earthquake hazard.
- ❑ Utah's older buildings and lifelines have low earthquake resistance.

There is a critical need for hazard-reduction measures, including risk identification and proper seismic-structural design and construction of buildings. Education, awareness, and preparedness are all necessary and important for Utah's residents.

STRATEGIES FOR EARTHQUAKE SAFETY

The following section lists the individual actions (strategies) that the USSC considers important to improve earthquake safety in Utah. It is not a comprehensive list and is not in order of priority. The strategies are divided into five categories to address the USSC's five key objectives:

1. Increase earthquake awareness and education.

2. Improve emergency response and recovery.

3. Improve the seismic safety of buildings and infrastructure.

4. Improve essential geoscience information.

5. Assess earthquake risk.

The first four categories correspond to topics assigned to the UEAB standing committees, and the corresponding strategies chiefly represent the work of those committees. Strategies in the fifth category (risk assessment) represent work that necessarily involves interdisciplinary input.

For each strategy, specific outputs are listed which can be measured to evaluate performance of the responsible parties in implementing the strategy. Also, the projected outcome is listed so that the ultimate goal of the strategy is known and success can be measured in light of this desired outcome. Background material explaining the need for the strategy is included, together with a brief discussion of ways to implement the strategy, a list of those responsible agencies (meaning those entities either having statutory responsibility or likely to take a leading role), and an estimate of resources needed. The latter are rough estimates which will be refined once the strategy is being considered for implementation. The list of strategies is meant to be a "living" list which can either be expanded as new actions are identified, or reduced as strategies are implemented and outcomes are achieved.

Objective 1:

Increase earthquake awareness and education.

STRATEGY: Inform citizens about earthquake hazards and risks.

OUTPUT: Information and training targeted to meet individual or collective needs.

OUTCOME: All citizens are better able to prepare for and respond to an earthquake.

Background

Different elements of Utah society have different needs for information and training to deal with mitigating and responding to the earthquake threat. There exists significant demand for earthquake education materials and services which should be appropriate, readily available, and user-friendly.

Implementation

Programs would be targeted to each of the following population segments with the corresponding products:

1. General public – A free Earthquake Awareness Guide of earthquake services and materials widely distributed.
2. School teachers – Science and safety instructional materials.
3. Businesses – Guides and training for earthquake preparedness in the workplace for managers and employees, techniques to reduce losses and resume operations quickly after a disaster.
4. Architects, engineers, contractors – coordination of materials and training through professional associations and licensing agencies.
5. Local government – awareness program of materials, services, and information on laws, procedures, rules, and standards.

Responsible Agencies

Utah Division of Comprehensive Emergency Management
American Red Cross
University of Utah Seismograph Stations
Utah Geological Survey
Utah Office of Education
Utah Division of Occupational/Professional Licensing
Utah League of Cities and Towns
Utah Association of Counties
Uniform Building Code Commission
Structural Engineers Association of Utah
American Institute of Architects, Utah Chapter
American Society of Civil Engineers, Utah Chapter
Association of Engineering Geologists, Utah Chapter

Resources Needed

First year: two person years: \$80,000; materials: \$75,000.
On-going: training: (1-3 FTEs) \$40,000 to \$120,000; materials: \$15,000.

STRATEGY: Incorporate earthquake education in school curricula.

OUTPUT: A multi-level curriculum for earthquake education in all public schools.

OUTCOME: All students are provided with earthquake science and safety training as a part of their regular education.

Background

More than 468,000 students (approximately 26% of Utahns) are in grades K-12 in Utah schools. Incorporation of earthquake science and safety in the school curriculum will better ensure student safety now and help produce educated citizens who will be able to make responsible decisions in the future.

Implementation

It would be most appropriate to focus efforts for lesson plans at grade levels 3, 5, and 9 in conjunction with earthquake science or related topics in the State Science Core Curriculum. The objective can be accomplished by doing the following: (1) educating the curriculum providers – district level school boards, school administrators, and teachers' unions – about the value of earthquake education in schools and the ease with which that can be implemented, (2) developing Utah-relevant earthquake education materials and a variety of options for implementation, (3) establishing certification standards for earthquake education programs, and (4) providing teacher in-service workshops. Resources to carry out this program must be provided or made available as opposed to redirecting existing resources.

Responsible Agencies

Earthquake Education Resource Group (includes Utah Geological Survey, University of Utah Seismograph Stations, and Utah Division of Comprehensive Emergency Management)
Utah Office of Education

Resources Needed

A task force composed of earthquake scientists and educators and members of the target audience (teachers and administrators) could develop and implement the entire project. Salaries would be needed for 1.5 FTE for three years as well as additional funds for office supplies and curriculum materials. The estimated total expenditure is $80,000 to $100,000 per year for three years.

STRATEGY: Disclose geologic hazards in real-estate transactions.

OUTPUT: Homebuyers are made aware of geologic hazards at a property prior to making a purchase.

OUTCOME: Homebuyers are more informed in their decisions.

Background

Buying a home is probably the greatest investment most families make in a lifetime. In making a decision on purchasing a home, they need accurate information. A commonly overlooked concern is geologic hazards because most homebuyers are unaware of geologic hazards and falsely assume that government would not allow homes to be built in hazardous areas. Homebuyers need to know the risks they are incurring. There is presently no easy way for homebuyers or real-estate agents to know if a property is vulnerable to geologic hazards.

A seller's disclosure form available to potential buyers would provide the necessary information. The Utah Association of Realtors has a voluntary disclosure form which includes geologic hazards that they recommend be used by all realtors. The Utah Division of Real Estate is presently developing a "property condition" disclosure form including geologic hazards which will be required in all transactions involving a real-estate broker, but it will not be required in non-brokered transactions.

Implementation

Disclosure can be implemented at either the state or local government level. Uniformity statewide is desirable, and would require legislation. Accurate maps showing geologic hazards are useful to inform sellers, real-estate agents, and local governments of potential hazards, but aren't necessary to implement disclosure if only known hazards or damage from hazards are to be disclosed.

Responsible Agencies

> Utah Division of Real Estate
> Local governments
> Utah Geological Survey (to provide hazards information)

Resources Needed

> If responsibility for disclosure is placed with sellers or real-estate agents, no government funding is necessary. Minimal costs may be incurred in handling paperwork. If the state places responsibility with local governments, state or local funds to handle additional paperwork may be required.

Objective 2:

Improve emergency response and recovery.

STRATEGY: Establish community emergency response teams (CERTs) statewide.

OUTPUT: Trained volunteer community emergency response teams exist statewide.

OUTCOME: Reduce life, property, and environmental loss by providing more immediate response in a disaster.

Background

In the immediate aftermath (first 72 hours) of an earthquake, standard emergency services will not be available. Research has shown that most rescues and emergency services are provided by untrained volunteers spontaneously functioning in damaged neighborhoods. This initiative would provide very basic training for interested people in fire safety, light rescue, disaster medical operations, hazard inspection, and other services. Grouped together within each community, as a part of neighborhood groups, church groups, or professional organizations, these volunteers would be in place to act independently and spontaneously in the event of a disaster, known and trusted by the people they are helping. These volunteers will respond to their neighborhoods first, then go to staging areas to assist their local government's disaster efforts.

Implementation

Four steps are required: (1) orient elected officials, policy makers, police, and fire and emergency management personnel in the use of volunteers in disaster response; (2) identify citizen groups and volunteer organizations; (3) distribute information and hold workshops through local public safety organizations and community service groups; and (4) continue to provide technical assistance and recertification to CERTs wishing to provide community-based relief. The steps would be accomplished under the direction of local Emergency Program Managers, with assistance of fire and rescue agencies to train volunteer community emergency response teams and team leaders.

Responsible Agencies

- Utah Division of Comprehensive Emergency Management (CEM)
- Local Emergency Program Managers
- Fire and medical agencies
- Community groups of all types

Resources Needed

Funding needed to provide CERT instructors to train local volunteers groups, to provide CERT safety equipment and basic supplies, and to manage and track statewide CERT teams and resources: approximately $100 per volunteer. Local governments within Salt Lake County began pilot training programs in 1994. Trainers currently volunteer their time free-of-charge. CEM would like to provide CERT training to 30 Utah communities with populations of 100,000 or less, annually. It would take about 15 years to offer training to most communities statewide. If training for two classes of 25 volunteers each are run in each of 30 communities, annual cost would be approximately $150,000.

STRATEGY: Develop effective exercise and training programs for hospitals.

OUTPUT: All hospital staff are trained for earthquake emergency response including implementing a standardized triage system.

OUTCOME: Hospitals are prepared for earthquake response.

Background

Past exercises have revealed inadequacies in response-related operations. Hospitals need to ensure their facilities are operational after an earthquake. This would require training and exercising hospital response plans, as well as interaction between hospitals and coordination with local emergency management officials. Hospitals need to routinely schedule exercises individually and in conjunction with other hospitals and local officials. All hospitals should exercise using a standardized triage system with universal triage tags. This system would save time, lessen confusion, and, most importantly, save lives. A universal triage system would be critical in mutual medical aid situations where emergency room staff are working in hospitals other than their own.

Implementation

There are six elements to preparing Utah hospitals for an earthquake emergency: (1) accurately identify each hospital's capabilities and seismic vulnerability; (2) enhance communication for air traffic at each hospital; (3) train hospital staff on ARES/RACES (amateur radio operators emergency systems) capabilities; (4) provide training as part of the hospital's policies; (5) establish continuing education goals; and (6) standardize hospital triage systems and encourage comprehensive seismic safety education programs for hospital personnel. Exercises to test hospital emergency response plans should be held periodically.

Responsible Agencies

- Utah Division of Comprehensive Emergency Management (CEM)
- Utah Hospital Association
- Utah Department of Health
- Local emergency management officials
- Local governments
- Local fire and police departments

Resources Needed

CEM's Exercise Program specializes in writing and conducting exercises. Developing and conducting a hospital-specific earthquake-scenario exercise centered around a standardized triage system would cost approximately $50,000.

STRATEGY: Enhance communication capabilities for emergency responders.

OUTPUT: Develop a communication system that will allow for the use of new technologies and provide the capability of expansion during peak disaster use.

OUTCOME: Emergency response capability will be enhanced because the new communication system will allow for the interoperability of agencies to meet the requirements of multi-agency response.

Background

Public safety and local governmental agencies in Utah currently operate radio systems in the VHF 150 and UHF 450 frequency band. The availability of additional frequencies in these two bands for system expansion is very limited. With the advancement of technology comes the responsibility to develop a system that will allow for the use of this new technology. We must ensure that the system allows for the interoperability of agencies to meet the requirements of multi-agency response. Most agree that radio coverage, combined with inadequate channel allocations, are the biggest problems in meeting the objectives of protection of life and property. During emergency situations, history continues to repeat itself with the inability of agencies to communicate with each other in an effective manner.

Implementation

A new communication network that will support both voice and data applications and accommodate current and future requirements needs to be developed. The system should support city, county, state, and federal agencies. All government agencies that are users or will have future communication needs will be requested to evaluate their present capabilities and their future communication requirements.

Responsible Agencies
- Utah Division of Information Technology Services
- Utah Department of Public Safety
- ARES/RACES (amateur radio operators organizations)
- Local governments
- State agencies

Resources Needed

An 800 MHz system is currently being evaluated for future communication needs for the state, including emergency response. Preliminary estimates indicate the initial phase of conversion from the present system will cost up to $10 million.

STRATEGY: Enhance the integrated emergency management system statewide.

OUTPUT: An integrated emergency management system at all levels of government and the private sector to protect life, health, property, and the environment.

OUTCOME: All jurisdictions and agencies can more fully utilize their resources to respond to any type of a disaster, including earthquakes.

Background

As Utah's population, infrastructure, and economy continue to grow, it becomes an increasing challenge for all agencies to inventory and utilize their resources. City, county, and state governments have designated Emergency Coordinators to prepare and conduct mitigation, preparedness, response, and recovery operations. These Coordinators are also responsible for exercising and evaluating their plans. Emergency planning and operation evaluation is an ongoing process. This should lead to a higher level of response proficiency.

Implementation

Encourage a full-time Emergency Coordinator for each state agency. Increase training in Integrated Emergency Management concepts. Continue to exercise emergency plans.

Responsible Agencies

- Utah Division of Comprehensive Emergency Management
- State Emergency Response Teams (SERT)
- County emergency management offices

Resources Needed

Funding for 1 FTE Emergency Coordinator in each of the 25 largest state agencies would cost approximately $48,500 per coordinator, or an approximate annual cost of $1,212,500.

Objective 3:

Improve the seismic safety of buildings and infrastructure.

STRATEGY: Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.

OUTPUT: Competent plan reviews are completed for new construction.

OUTCOME: Help ensure that new buildings are being designed safely by competent professionals to withstand seismic forces.

Background

Many municipalities have some form of plan review to ensure that buildings are being designed in accordance with the Uniform Building Code (UBC). However, a lot of buildings are built which do not meet current seismic code requirements, particularly in rural portions of Utah where plan checking is not performed.

Implementation

Mandate that important structures, such as schools, hospitals, or emergency response facilities, particularly those located in seismic zone 3, have a plan review by a competent professional before a building permit is issued. Require plan reviews on all construction over a certain height and/or size in cities and towns located in nonrural counties, particularly Davis, Utah and Salt Lake.

Responsible Agencies

- Structural Engineers Association of Utah
- International Conference of Building Officials, Utah Chapter
- Local governments

Resources Needed

Salary of competent in-house reviewer: \$35,000 to \$60,000 per year; or outside consultants: \$500 to \$2,000 per structure.

STRATEGY: Enforce the state amendment to the Uniform Building Code which requires building owners to install roof anchors and parapet bracing when reroofing their buildings.

OUTPUT: Copies of the amendment are distributed to building officials, architects, and engineers through the media and professional societies, and education programs are conducted.

OUTCOME: A gradual decrease in the seismic hazard posed by existing unreinforced masonry buildings.

Background

Unreinforced masonry structures built prior to 1976 pose a great risk to life safety during even moderate earthquakes. The weakest structural link is frequently the connection between the roof structure and supporting walls. A failure at this location can lead to collapse of the roof. Also, unreinforced parapets and appendages are particularly vulnerable to collapse if not properly anchored.

The logical time to perform this work at least expense is during reroofing when the roof structure is exposed, and new ties and braces can be easily installed. Ordinances similar to the amendment have worked successfully in Ogden and California cities.

The Uniform Building Code (UBC) Amendment was passed by the Utah UBC Commission in 1993, but has not been enforced, partially due to lack of knowledge of the amendment by building officials, or by building owners contracting reroofing without first obtaining a building permit, thereby bypassing the amendment requirement.

Implementation

Educate building officials, engineers, and architects of the amendment through the media, professional organizations, and the State Division of Occupational/Professional Licensing. Enforce the requirement to obtain a building permit before allowing people to reroof their buildings.

Responsible Agencies

Structural Engineers Association of Utah
American Institute of Architects, Utah Chapter
International Conference of Building Officials, Utah Chapter
Division of Occupational/Professional Licensing
Uniform Building Code Commission

Resources Needed

Minimal.

STRATEGY: Improve the post-earthquake operational status of essential service buildings.

OUTPUT: All essential government services buildings are identified. Buildings constructed before 1976 are retrofitted or relocated as needed, to meet standards that will allow them to remain operational after earthquakes.

OUTCOME: The ability to provide uninhibited disaster relief services.

Background

Lessons learned in recent damaging earthquakes demonstrate the need to continue essential government services during and after an earthquake. Many facilities constructed during periods when codes were not as comprehensive as current codes have sustained damages that restrict their use after an earthquake. Precautions must be taken to determine acceptable levels of facility performance to ensure post-earthquake availability of functions. Older essential services buildings that house emergency operations centers, law enforcement offices, and fire stations may not be able to remain functional after earthquakes. The potential loss of these functions poses an unacceptable risk because it would slow emergency response and result in unnecessary casualties and property damage.

Implementation

Using a uniform assessment procedure, the cataloging of location, hazard type, and structure vulnerability should be undertaken. Retrofit or relocation possibilities are then analyzed. Cost/benefit information is compiled and analyzed. Mitigation is then undertaken on a priority basis.

Responsible Agencies:
- Local governments
- Utah Division of Facilities Construction and Management

Resources Needed

A rapid visual screening assessment costs approximately $1,500 per building.

Funding to rehabilitate the facilities on a priority basis depends on results of assessment.

STRATEGY: Reduce structural hazards of government-owned buildings.

OUTPUT: Government-owned buildings structurally modified to better withstand earthquakes.

OUTCOME: A safer environment to conduct government business.

Background

State and local governments own a great number of buildings. Some have unreinforced masonry walls or are made of nonductile concrete or other materials likely to collapse during an earthquake. In past earthquakes, these facilities have suffered higher losses than other construction-type facilities. The public, government employees, and government functions—including many emergency services—are at risk because of these buildings. The state owns approximately 4,500 buildings of which approximately 2,300 would be considered essential in the event of a catastrophic event.

Implementation

Complete a program to ensure that major state government buildings can withstand an earthquake to the extent that collapse is precluded, occupants can exit safely, and functions can be resumed or relocated promptly consistent with the need for these services after earthquakes. Essential buildings would need to be identified and prioritized in terms of the necessity for their use to supply essential services after a catastrophic event. ATC-21, the rapid visual screening of buildings for potential seismic hazards could then be used to identify buildings by design and vulnerability parameters. Based on these parameters, buildings should then be prioritized by order of essential need and vulnerability to a seismic event. Detailed evaluations and cost estimates should then be generated for the retrofitting or replacement of each of the facilities, including a timetable for completion of the work.

Responsible Agencies

> Utah Division of Facilities Construction and Management
> Local governments

Resources Needed

> Rapid visual screening to identify and catalogue government buildings structurally at risk in a seismic event averages $1,500 per building. Funding to conduct geologic investigation of the building site averages $2,000 per site. The total cost to evaluate 2300 essential state-owned buidings would be $3,450,000 for the buildings themselves and $4,600,000 for the geologic site evaluations, or approximately $8,050,000.
>
> Cost for detailed evaluation of at-risk government buildings averages $5,000 per building when done on individual buildings. Evaluations conducted on groups of buildings can be considerably less costly.
>
> Costs to upgrade government-owned buildings ranges from $8.75 to $18.00 per ft^2. Cost to carry out needed seismic upgrade of buildings will depend on results of assessment.

STRATEGY: Mitigate nonstructural hazards in government-owned and leased buildings.

OUTPUT: Assess hazards in government-owned buildings and upgrade as necessary.

OUTCOME: A safer and operational working environment for government agencies following an earthquake.

Background

Falling hazards to occupants and visitors can be posed by nonstructural building elements such as parapets, cornices, ceiling and lighting systems, window and building cladding systems, air conditioning, and plumbing and electrical equipment. These hazards are significant to the continuity of building functions following earthquakes.

The seismic safety of nonstructural elements in all new construction is largely regulated by building codes. Before 1976, however, most building codes failed to explicitly regulate the seismic safety of nonstructural elements. As a result, nonstructural elements in older buildings are often unbraced or unattached to the structure and can fall or move excessively during earthquakes.

Implementation

Perform an evaluation of government-owned and leased buildings with regard to falling hazards in existing nonstructural building elements. The evaluation would identify and prioritize these elements with regard to level of danger presented. A cost estimate for correcting each hazard would be part of the evaluation. Upon completion of the evaluation, appropriate action can be undertaken.

Responsible Agencies

Utah Division of Facilities Construction and Management
Agencies and institutions that are responsible for facilities
Local governments

Resources Needed

If evaluation of nonstructural hazards is performed during investigation of structural hazards (see Strategy 3.4) in the same building, additional cost would be approximately $100 per building.

Cost to carry out seismic upgrade will depend on results of evaluation.

STRATEGY: Improve safety of older public school buildings.

OUTPUT: Identify and reduce structural and non-structural seismic hazards in all pre-1976 public school facilities.

OUTCOME: Safer facilities for students and teachers, as well as buildings useable in an emergency.

Background

A large number of public school buildings were designed prior to the 1976 Uniform Building Code seismic requirements. Additionally, some recent portable classrooms may not be adequately anchored to their foundation. Many schools have free-standing bookshelves, file cabinets, and other heavy shelved items that are not secured and may cause harm. A major earthquake may cause significant property damage and injury to students and teachers. Additionally, these damaged structures will not be available for disaster relief efforts.

Implementation

Identify all schools and their associated hazard, structural, and non-structural problems. Initiate plan to mitigate, rebuild, or relocate the public school structures, and create a priority list to determine which buildings are the most hazardous. Study minimal cost methods of partially retrofitting schools, such as providing connections between wall and roof structures.

Responsible Agencies

Utah Office of Education
Individual school districts

Resources Needed

Funding for seismic studies provided in school district taxing policies. Studies by Salt Lake School District averaged $1,000 per building. These studies were done on a group basis. A projected range would be from $500 to $5,000 per building, and would depend on the complexity of the structure and the degree of detail required in the study. Over one-third of these assessments have already been done. Total cost for assessments of all school buildings would be on the order of $720,000.

Funding and technical expertise for seismic upgrades also funded by school district taxing. Costs for upgrades in Salt Lake averaged $833,333 per school, but costs will vary as indicated in the assessments. If the statewide average upgrade costs $500,000 per school, the total cost would be about $300 million.

STRATEGY: Improve safety and operational ability of older hospital buildings.

OUTPUT: Assess earthquake vulnerability of all hospitals and upgrade the structures to better survive an earthquake.

OUTCOME: Safe structures that will provide a more secure environment for patients and staff and improved ability to survive an earthquake and provide disaster relief.

Background

Many Utah hospitals were designed prior to the 1976 Uniform Building Code seismic requirements. A major earthquake may cause significant property damage and injury to patients and health-care providers. Of equal concern, these damaged structures will not be available for disaster relief efforts after an earthquake.

Implementation

Hospitals should remain operational after an earthquake. A risk and vulnerability analysis of the structures should be performed. Upgrade the structural and non-structural components as required.

Responsible Agencies

Uniform Building Code Commission
Utah Division of Comprehensive Emergency Management
Privately owned and county hospital organizations

Resources Needed

Cost of seismic studies could range anywhere from \$1,000 to \$10,000 per structure depending on building size, complexity, and degree of detail desired in the study. Many Wasatch Front hospitals have already been evaluated.

Cost for seismic upgrades depend upon vulnerability but can be generalized between \$8.75 to \$25.00 or more per ft^2.

STRATEGY: Improve safety of older high-occupancy buildings (250 persons or more) to be structurally competent enough to withstand moderate to large earthquakes.

OUTPUT: Assess seismic vulnerability of all older high-occupancy structures and retrofit or disclose building condition upon resale.

OUTCOME: Prevent collapse in the event of an earthquake, thus reducing life loss, property loss, potential secondary effects, and reconstruction costs.

Background

High-occupancy buildings designed prior to the 1976 Uniform Building Code seismic requirements are of special concern because of the potentially significant loss of life and injury. Efforts should be made to insure against structural collapse and non-structural failure.

Implementation

Identify all high-occupancy buildings in the state. Assess each structure to determine vulnerability and propose mitigation techniques and costs. Require disclosure of hazards and building condition upon resale. Find funding sources and incentives to help building owners mitigate the hazards. A publication by the Applied Technology Council (ATC-33) provides seismic rehabilitation guidelines for existing buildings.

Responsible Agencies

- Utah Division of Comprehensive Emergency Management
- Uniform Building Code Commission
- Local governments

Resources Needed

Cost of vulnerability studies are approximately $1,000 to $4,000 per building.

Cost for seismic upgrades for public facilities is $5 to $25 or more per ft^2.

Technical expertise and guidelines for seismic upgrades.

Local government agencies enact and enforce new regulations.

STRATEGY: Improve the seismic safety of older homes.

OUTPUT: Create and distribute maps of seismic-hazard areas and upgrade information packets, procedural manuals, standards, and requirements to all affected home owners, all real-estate agents, building contractors, and lending institutions. Establish funding sources and incentives to encourage seismic-safety retrofitting.

OUTCOME: Improved safety and lower repair costs in the event of an earthquake.

Background

There are many unreinforced masonry houses along the Wasatch Front which are susceptible to seismic damage. Many older frame houses were built without adequate anchorage to their foundations. Water heaters and other non-structural elements are usually not anchored to resist earthquakes.

Implementation

The first step is to create and distribute an information packet describing hazards, general procedures, standards, funding sources, and incentives to the homeowners. Technical and procedural documents are to be made and dispensed upon request. Funding and incentive packages should be created by public and private industries such as insurance and mortgage companies. One publication, available through the Utah Division of Comprehensive Emergency Management, describes methods for seismically upgrading older, unreinforced masonry homes.

Responsible Agencies

Utah Division of Comprehensive Emergency Management
Utah Division of State History
Uniform Building Code Commission
Real-estate, insurance, and mortgage groups

Resources Needed

Cost to develop a household earthquake upgrade information packet and technical and procedural documentation (booklets available through State agencies and from the Federal Emergency Management Agency) approximately $40,000.

Financial incentives to encourage homeowners to make seismic retrofits.

STRATEGY: Improve safety of mobile homes.

OUTPUT: Seismically brace all new mobile homes; retrofit inadequately braced existing mobile homes at time of resale. Create and implement incentive packages to encourage mobile home owners to retrofit existing installations.

OUTCOME: Increased safety for occupants, reduced amounts of utility rupture and associated hazards and repair costs.

Background

Mobile homes are extremely vulnerable to earthquake damage. Since mobile homes are virtually never connected to a foundation, they tend to fall off their supports during an earthquake, often severing their typically rigid gas and water connections. This can lead to fire and rupture of water lines.

Implementation

Identify locations where bracing and retrofitting is appropriate. Legislation is needed to require new mobile homes to be seismically braced and existing mobile homes be retrofitted at time of resale. Provide tax or insurance incentives to those who mitigate.

Responsible Agencies

Utah Division of Motor Vehicles
Local government

Resources Needed

Cost of seismic bracing on new installations will be part of the installation price paid by homeowners but is unknown at this time.

Provide financial incentives to retrofit existing installations. California requirements and industry standards for wind anchorage can accomplish retrofit requirements if enforced.

Local governmental agencies enact and enforce new regulations.

STRATEGY: Prevent loss of historic buildings.

OUTPUT: Vulnerability assessments and mitigation completed on buildings on the National Historic Register.

OUTCOME: The preservation of historic buildings and their associated heritage in the event of an earthquake.

Background

Utah's designated historic buildings are an irreplaceable cultural resource. Many of these structures are likely to be damaged beyond repair by an earthquake. The problem is compounded by the lack of funding to reinforce these buildings in a way that preserves their historic and architectural qualities. After an earthquake, damaged historic buildings should not be demolished without thorough review.

Implementation

Identify and then reduce seismic hazards in all "National Register" historic buildings. Provide mitigation solutions and aid in the creation and acquisition of funds needed to make the necessary upgrades.

Responsible Agencies

Utah State Historical Society for privately owned buildings
Utah Division of Facilities Construction and Management for state buildings

Resources Needed

Funds needed for assessments on approximately 1,000 sites. Assessment and retrofit costs for historic structures are much higher than for other buildings.

Money and technical expertise for seismic upgrades depends on results of assessments.

STRATEGY: Improve lifeline survivability in the event of an earthquake.

OUTPUT: Assess and mitigate earthquake hazards on all lifelines.

OUTCOME: Functional or easily/rapidly repairable lifelines after a earthquake.

Background

Critical elements of the infrastructure of many utilities and other lifelines are vulnerable to damage during earthquakes. Within the electric power network, porcelain insulators and certain pole-mounted transformers may have a high probability of failure. Telecommunications switching equipment, as well as transceiver towers and conduits may be displaced or moved out of alignment. Liquid and gaseous fuel pipelines and petrochemical tanks may be displaced or ruptured.

Implementation

State, county, and local public works departments in conjunction with utilities should survey, inventory, and assess the condition of their respective lifelines. Upon completion of the assessment, plans for mitigation and or replacement should be developed and implemented. Emergency response plans should be developed, and seismic considerations incorporated into the design of new lifelines.

Responsible Agencies

Utah Public Service Commission
Uniform Building Code Commission
Federal Energy Regulatory Commission
Municipal and private utilities and pipeline operators

Resources Needed

Regulatory rate consideration from Utah Public Service Commission, Federal Energy Regulatory Commission or local government.

Cost for assessing lifeline vulnerability not available at this time.

Cost for lifeline upgrades depends upon results of assessments.

STRATEGY: Improve earthquake performance of water and waste-water systems.

OUTPUT: Establish appropriate and practical uniform safety and emergency response plans for all water and waste-water systems.

OUTCOME: Improved safety, performance, and reliability of water and waste-water systems.

Background

Culinary and waste-water systems include aqueducts, pumping stations, transmission pipelines, water and waste-water treatment facilities, distribution and collection pipe networks, and distribution storage tanks and reservoirs, all of which are vulnerable to earthquakes. Water and waste-water systems can be rendered inoperable because of damage to tanks, reservoirs, treatment facilities; broken transmission mains; failures at pipe joints; and failed equipment. Damages from water sloshing in tanks and clarifiers is unavoidable during earthquakes, but economical, preventive measures can be taken to reduce the amount of damage and recovery time after earthquakes. Many of the state's water systems' transmission mains and aqueducts cross active faults and dormant landslide zones, and are vulnerable to fault rupture or earthquake-caused slope failure. Because most of the transmission systems are underground, localized damage to such systems is unavoidable. Water and waste-water systems should stockpile replacement components needed after earthquakes.

Implementation

All water and waste-water systems should be inventoried to assess their earthquake performance. All water and waste-water systems would identify and report their emergency-response plans and procedures for the timely repair or replacement of earthquake-damaged water and waste-water systems. Establish appropriate and practical, uniform seismic-safety criteria and procedures and adopt a comprehensive policy on acceptable levels of earthquake risk in water systems. A report should be made to the state legislature that will make recommendations for any additional authority needed to develop and enforce an effective policy on acceptable earthquake risk, including uniform seismic-safety standards, and emergency-response and recovery plans if required.

Responsible Agencies

Utah Department of Environmental Quality
Water system owners (local governments, sanitation districts, etc.)
Waste-water system owners (local governments, sanitation districts, etc.)

Resources Needed

Cost to assess systems not available at this time.

Cost to the state to establish safety criteria and policies on acceptable risk unknown at this time.

Cost to upgrade systems depends upon results of assessments.

Objective 4:

Improve essential geoscience information.

STRATEGY: Reduce earthquake losses by mapping and identifying geologic hazards.

OUTPUT: Hazard maps for all earthquake-prone urban areas.

OUTCOME: Development and management are safer, more reasoned, and more cost-effective.

Background

Strong ground shaking, liquefaction, slope failure, surface fault rupture, and other forms of ground failure are responsible for most losses caused by earthquakes. Changes in ground water conditions caused by earthquakes can also have major, sometimes permanent, consequences. Areas subject to these hazards need to be identified and mapped by qualified professionals so that information can by used by local governments in land-use ordinances and by others in adequately considering geologic hazards in development and management. Geologic-hazard maps for certain hazards are complete for much of the Wasatch Front from Ogden to Provo, but remain to be done in other urban areas subject to earthquake hazards. The Utah Geological Survey (UGS) has a long-term goal to complete these maps statewide, but the process will take decades. To accelerate the program, 1-2 additional UGS staff would be needed. To help ensure that local governments use the maps, UGS presently requires contributions from local governments. Experts in the private/academic sector may also complete some the hazard mapping. Certain hazards such as strong ground shaking require additional research and data collection to develop suitable databases and techniques to produce maps.

Implementation

Geological hazards mapping is ongoing at the UGS and will continue. Maps for some hazards could be completed by university or private-sector specialists.

Responsible Agencies

- Utah Geological Survey
- Local governments
- University geology departments, private geologists

Resources Needed

- UGS staff (1-2 FTE's): $40,000 to $80,000 per year.
- Local government cost sharing: $5,000 to $10,000 per city.
- Private/academic mapping: $50,000 to $100,000 per project.

STRATEGY: Perform geologic-hazards investigations for critical public facilities.

OUTPUT: Geologic-hazard investigations are performed for all new critical public facilities.

OUTCOME: Critical facilities will not be sited in hazardous areas and, in the event of a natural disaster, facilities that are needed for emergency response will remain intact.

Background

Critical public facilities (schools, water tanks, public-safety buildings, etc.) are still being sited in hazardous areas, sometimes with no knowledge of hazards and sometimes with knowledge coming too late to abandon sites or alter designs without incurring great additional expense. Many governments require private developers to consider geologic hazards, but do not themselves consider hazards in locating their own buildings.

Certain public buildings are critical for public safety during and after a disaster. These buildings must not be vulnerable to geologic hazards that could endanger occupants or reduce functionality following a disaster such as an earthquake when they are needed most. The consequences will be reduced capacity to house and feed those needing shelter after a disaster, reduced response capability, possible loss of life in public buildings with accompanying liability, and government losses due to property damage.

Implementation

Legislation could be passed requiring such investigations, performed either by the private sector or by the Utah Geological Survey (UGS).

Responsible Agencies

- Local governments
- Utah Geological Survey
- Utah Division of Facilities Construction and Management (DFCM)

Resources Needed

DFCM already requires such investigations by the private sector for buildings they administer as a part of their building costs. Local governments would similarly need to fund such costs if done by the private sector. Under the Utah Code, the UGS is charged to perform geologic-hazards investigations for schools and local government critical facilities, but because of declining budgets the UGS cannot take on an increased workload without additional funding. The UGS may need 1-2 additional staff ($40,000 to $80,000 per year) to perform these studies, depending on workload.

STRATEGY: Make land use compatible, through local government ordinances, with known hazards.

OUTPUT: Local governments are encouraged or required to adopt geologic-hazards ordinances as needed.

OUTCOME: Land use is safer and consistent with identified geologic hazards.

Background

In Utah, local governments regulate land use. One critical life-safety and property-loss element that should be considered in land use is geologic hazards. Land uses must be compatible with hazards present, and often hazards must be reduced prior to use.

Damages from unwise land use in Utah have principally been from landslides, debris flows, flooding, and soil-foundation problems. However, earthquakes present the potential to cause damage and life-loss far exceeding that from other hazards. This potential loss can be reduced by prudent land use. Governments may be incurring liability by allowing development in hazardous areas.

Implementation

Legislation or state policy requiring (or encouraging) local governments to adopt geologic-hazards ordinances is needed. Many local governments already have such ordinances but do not adequately enforce them. Once implemented, geologic assistance from the Utah Geological Survey (UGS) to review reports will be required. Sample ordinances and guidelines for developing and enforcing ordinances are already available.

Responsible Agencies

Local governments
Utah Geological Survey

Resources Needed

No legislative appropriation is necessary; costs principally to be born by private developers, typically $1,000, perhaps up to $3,000 per project. Some staff costs to enact ordinances will be incurred by local governments, and costs to provide technical assistance to enforce ordinances will be incurred by the UGS. Costs for report reviews can be passed on to developers. Total costs to developers statewide would be on the order of $300,000 per year (based on 250 studies per year).

STRATEGY: Ensure design professionals and building officials are kept current on relevant geoscience information.

OUTPUT: Periodic meetings of geoscientists, engineers, and building officials to discuss implications of geoscience information to building safety.

OUTCOME: Up-to-date, reliable geoscience information is used to guide the safe and economical earthquake-resistant design of new buildings.

Background

Seismic requirements for construction in Utah are contained in the Uniform Building Code (UBC), adopted statewide in 1987. UBC requirements are based on two geoscience factors: (1) the seismic zone rating taken from the UBC Seismic Zone Map (derived from a map of peak horizontal ground accelerations with a 10 percent probability of being exceeded in 50 years) and (2) the site coefficient, taken from site soil information. Information with relevance to seismic zone factors and site coefficients is constantly evolving through scientific research and experience in recent earthquakes.

Geologists, seismologists, and geotechnical engineers must look at new information and lessons learned in recent earthquakes with regard to their implications for building safety in Utah, and keep structural engineers, building officials, and policy-makers aware of pertinent findings and their implications to building codes.

Implementation

New geologic, geotechnical, and seismologic (particularly strong-motion) data must be analyzed and applied to building safety. Various disciplines must coordinate activities and perform evaluations and reviews of pertinent information.

Responsible agencies

- Utah Geological Survey
- University earth-science and engineering departments
- American Society of Civil Engineers, Utah Chapter
- Association of Engineering Geologists, Utah Chapter
- Structural Engineers Association of Utah
- International Conference of Building Officials, Utah Chapter
- American Institute of Architects, Utah Chapter
- Uniform Building Code Commission

Resources Needed

Resources are needed for participation in post-earthquake investigations and key conferences and to convene local workshops; approximately $10,000 per year.

STRATEGY: Determine appropriate seismic criteria and procedures for evaluating performance of existing dams.

OUTPUT: Guidelines for seismic safety assessments of existing dams.

OUTCOME: Uniform, state-of-the-art assessments of seismic safety of dams.

Background

The State of Utah has a program for protecting public health and welfare by regulating the safety of several hundred existing dams. Among the issues considered in this program is the performance of dams under seismic loading. Current regulations require estimation of the maximum acceleration and an "operating-basis" acceleration at each dam determined to have questionable future performance. These regulations require embankments to have "acceptable" deformations under maximum acceleration loading and essentially no deformations under the operating-basis acceleration. The reliability of deformation predictions is of concern with respect to public safety. Are procedures for predicting earthquake ground motions and embankment deformations sufficiently reliable that relatively little post-deformation freeboard should be required? Or are these procedures sufficiently uncertain that the predicted deformations could result in dangerous overtopping? Should the operating basis acceleration be defined as the largest likely to be experienced during the useful life of the dam or a period of economic depreciation?

Costs of rehabilitation of existing dams can be extremely high, and many dams are owned by rural water districts that depend on the water but do not have spare financial resources. The State is charged with protecting public health, safety, and welfare; the dam owners are charged with maintaining their facilities and providing water for the welfare of people in their service areas. Accurate acceleration values and reliable procedures for evaluations of dam seismic response are important for state agency personnel and dam owners to maintain safe and economical dams.

Implementation

This strategy requires two parts: (1) a detailed evaluation of maximum earthquakes together with attenuation of ground motion with distance, and (2) a detailed evaluation of the reliability of alternative procedures for predicting the seismic response of dams.

Responsible Agencies
Utah Department of Natural Resources, Division of Water Rights

Resources Needed
Research for this initiative is estimated at $200,000 over a two-year period.

STRATEGY: Reduce earthquake-induced liquefaction risk to highway structures.

OUTPUT: Identify all hazardous bridges; generate a plan for mitigation of each structure.

OUTCOME: Highway bridges are safer in the event of earthquake-induced liquefaction.

Background

Earthquake-induced liquefaction is a major cause of earthquake damage to bridges. Areas prone to liquefaction include floodplains and other lowland areas where water tables are shallow and sediments are of recent deposition. For example, 266 highway and railway bridges were damaged or destroyed during the great 1964 Alaska earthquake due to ground displacements generated by liquefaction. Similar, but less extensive bridge damage occurred during earthquakes near Charleston, South Carolina, in 1886; San Francisco, California, in 1906 and 1989; and in the Imperial Valley of California in 1979.

Several areas of Utah have been identified as susceptible to liquefaction during moderate to large earthquakes. Some segments of major roadways, including Interstate highways and primary arteries, and many segments of secondary routes cross these potentially hazardous areas. A survey of bridges and bridge sites is needed to assess which bridges may be vulnerable to liquefaction-induced damage. This assessment could then be used to develop a mitigative plan to prevent or minimize damage and disruption to the highway system during future earthquakes.

Implementation

An assessment should be made of highway bridges in the state to determine their vulnerability to liquefaction-induced damage. Plans should then be made to reduce hazards through retrofit or replacement.

Responsible Agencies

Utah Department of Transportation
Help from specialists from universities and other state agencies in Utah

Resources Needed

Funding needed for assessment: $300,000.

Cost of mitigation depends on results of assessments.

STRATEGY: Determine appropriate seismic design coefficients for highway bridges.

OUTPUT: Calculate and incorporate new seismic design coefficients in design work for new bridges associated with the widening of I-15.

OUTCOME: (1) Ensure that the best available information is used for the safe and economical design of the new bridges. (2) Prevent the need for retrofit of the bridges in the near future. (3) Reduce bridge damage in an earthquake.

Background

The design of new bridge structures for the I-15 corridor requires scientists and engineers to determine the seismic forces which will act on the bridge. Recent experiences in California indicate that soft deep and stiff shallow soil profiles can significantly affect ground motions at a site. While studies and evaluations of various soil types have been prepared in California, the results of these evaluations are not directly transferrable to the existing conditions in Utah.

There is considerable uncertainty regarding appropriate design accelerations for bridges in Utah. Examining the similarities in soil conditions and the potential for large earthquakes, current design requirements in Utah appear to be unsafe based on California's experience. However, direct application of design accelerations used in California may be overly conservative because of differences in the rates of earthquake occurrence in Utah and in California. Because bridge structure (superstructure and foundation) costs and earthquake resistance can vary significantly depending of the correct design acceleration coefficient, it is important to accurately estimate this value for safe and economical design.

Implementation

This strategy would require detailed subsurface investigations (to 200 ft) at several bridge sites with soil profiles typical of that along the I-15 alignment. Based on the soil information which is collected, computer models will be used to predict the ground motions which would develop for a number of potential earthquakes.

Responsible Agencies

Utah Department of Transportation
Help from specialists from universities within Utah

Resources Needed

It is estimated that costs for necessary geotechnical studies will total approximately $300,000.

STRATEGY: Develop incrementally a strong-motion program.

OUTPUT: Deploy at least 108 accelerographs in the seismic regions of the state to record strong ground shaking.

OUTCOME: The hazard of strong ground shaking from local earthquakes is better quantified so it can be correctly incorporated into safe, cost-effective design of buildings and other structures. Key information can also be rapidly available for crisis management.

Background

Measurements of actual ground-shaking are essential to ensure that buildings and structures in Utah are neither under-designed, posing a life-safety threat, nor over-designed, wasting precious resources. Engineers need, but lack, recordings of strong ground shaking from Utah earthquakes to design and construct earthquake-resistant structures (including buildings, highways, and dams) that are cost-effective. A 1989 blue-ribbon panel of national earthquake experts recommended that to obtain the necessary data, a minimum of 108 new strong-motion recording instruments (accelerographs) be installed in Utah. In 1992 the Utah Legislature appropriated $75,000 to the Utah Geological Survey (UGS) to begin a strong-motion instrumentation program, and an advisory committee of engineers and scientists was formed to guide the program. But funding was discontinued after one year. The need for strong-motion data for earthquake engineering persists--to be able to predict reliably what strong ground shaking must be anticipated and to know what forces damaged structures have experienced. Recent California earthquakes also emphasize that crisis managers quickly need reliable information on the severity and geographic extent of strong ground shaking for emergency response.

Implementation

The UGS and its strong-motion advisory committee believe that a viable strong-motion program can be established and maintained through an incremental approach. With creative planning, instruments can progressively be spread throughout the seismically dangerous areas of the state to optimize the chance of recording strong ground shaking wherever it occurs. To the extent feasible, innovative instruments will be purchased to allow at least some capability for rapidly assessing strong-motion information within minutes of a sizable earthquake along the Wasatch Front urban corridor in order to direct appropriate levels of response.

Responsible Agencies
- Utah Geological Survey
- University of Utah Seismograph Stations

Resources Needed
- To purchase, deploy, and maintain 108 instruments over 20 years would have an annual ongoing cost of $150,000.

STRATEGY: Develop a statewide, real-time earthquake monitoring system.

OUTPUT: (1) Increased number of seismically vulnerable counties and cities in Utah for which continuous and accurate instrumental earthquake data are available. (2) Rapid emergency alert, within minutes after the occurrence of an earthquake in the Utah region, to state-agency officials, emergency managers, and the general public.

OUTCOME: Collect and distribute data needed (1) for more cost-effective earthquake engineering, (2) for more rapid and effective emergency response, (3) to reliably quantify earthquake dangers, and (4) to improve scientific understanding of local earthquake behavior, in order to better mitigate effects.

Background

Instrumental earthquake recording provides essential information needed by many state agencies and local governments for rapid emergency response, for the reliable assessment of earthquake hazards and risk, and for safe cost-effective earthquake engineering. Utah's existing seismographic network, operated by the University of Utah Seismograph Stations (UUSS), does not provide adequate instrumental coverage of many seismically dangerous parts of the state—especially outside the Wasatch Front area. Strong-motion instrumentation in Utah is greatly inadequate. Available technology, which is becoming commonplace elsewhere, needs to be incorporated to ensure automated, rapid communication of vital information—including the extent and severity of strong ground shaking—to emergency managers within minutes after any significant earthquake.

Implementation

The UUSS needs to transform Utah's existing seismographic network into a statewide, real-time earthquake monitoring system. This can be progressively accomplished in 5 years, providing coverage of all high-risk areas of Utah. Capabilities for real-time data processing and automated post-earthquake alert can be added to Utah's existing seismic network, but without effective coverage of rural Utah.

Responsible Agencies

- University of Utah Seismograph Stations
- Utah Geological Survey
- Utah Division of Comprehensive Emergency Management
- Utah Division of Information Technology Services

Resources Needed

The costs for a modest, but effective, state seismic system will require a one-time capital investment of approximately $1 million and additional ongoing costs of approximately $150,000 per year.

STRATEGY: Monitor faults using Global Positioning System (GPS) measurements.

OUTPUT: Regular monitoring of a network of GPS benchmarks.

OUTCOME: Strain buildup and ground deformation associated with faults are understood on a very detailed level, allowing more accurate estimation of the likelihood of large earthquakes and accompanying hazards.

Background

Precise surveys of ground deformation across active faults using GPS technology are a fundamental technique in modern earthquake monitoring. GPS has become the principal tool used in the National Earthquake Hazards Reduction Program for measuring the cycle of ground deformation before, during, and between large earthquakes. The value of GPS surveying was recently demonstrated in the Los Angeles basin where ground deformation was observed prior to the 1994 Northridge earthquake, indicating that rupture was likely on hidden faults such as the one that produced the magnitude 6.7 quake.

GPS measurements are particularly important in Utah for: (1) understanding how fast Utah's normal faults accumulate strain energy prior to large earthquakes, (2) assessing the likely locations and timing of future earthquakes, especially along the Wasatch fault, (3) identifying hidden faults that may underlie Utah's densely populated valleys, and (4) evaluating how the broad warping of the earth's surface during future large earthquakes may cause Great Salt Lake or Utah Lake to inundate neighboring areas.

Implementation

Utah needs a statewide network of GPS survey benchmarks that are systematically observed with a pool of at least five GPS receivers. This effort requires (1) a plan for periodic and prioritized surveys of Utah's major active faults, and (2) integration of GPS data collection with other earthquake monitoring and with high-precision surveying for state, county, and local engineering. A stable long-term funding base is essential.

Responsible Agencies

University of Utah Seismograph Stations
Utah Geological Survey
County Surveyors: Salt Lake, Davis, Weber, Box Elder, Utah, among others

Resources Needed

Approximately $150,000 would be required for one-time acquisition of five dual-frequency GPS receivers, together with ancillary equipment. Recurring costs for field operations, data processing, data archiving, equipment upgrades, and coordination with cooperating agencies would require about $70,000 per year.

Objective 5:

Assess earthquake risk.

STRATEGY: Update estimates of direct losses expectable from earthquakes.

OUTPUT: Comprehensive studies to estimate the potential losses of life, number of injuries, and damages to structures and lifelines from earthquakes of various magnitudes and locations.

OUTCOME: Earthquakes are placed in a proper policy perspective based on credible projections of losses and societal impacts; emergency planning is improved; and long-term hazard-reduction activities are prioritized.

Background

Utah's last comprehensive forecast of earthquake losses was published in 1976 and is out of date. Subsequent studies have restrictively analyzed losses, say, to buildings only, or apply to restricted areas, such as Salt Lake County. In 1991, the Federal Emergency Management Agency (FEMA) funded the non-profit, California-based Applied Technology Council (ATC) to develop methods to estimate losses, including casualties, and apply these methods to estimate losses associated with a magnitude 7.5 earthquake in Salt Lake County. This and a study by the University of Utah Geography Department considered only losses in Salt Lake County. FEMA and the National Institute of Building Sciences (NIBS) have also developed a draft methodology (planned for release in 1996) to estimate earthquake losses at various levels of detail, depending on available data bases and technical experience of those performing the analysis.

Implementation

In order to establish credible forecasts of earthquake losses in Utah, various methodologies, together with available information, must be carefully evaluated. This will require close coordination among technically diverse experts and the use of both scenario-based and probabilistic risk methods for damage and casualty estimates. Available methodologies include those developed by the ATC, FEMA/NIBS, and the University of Utah Department of Geography. The Utah Seismic Safety Commission can provide a suitable forum for coordinating the interdisciplinary teams and studies required to produce well-founded estimates of direct losses expectable from earthquakes in Utah. These estimates must account for significant differences due to time of day and season. Also, loss estimates are needed for specific classes of buildings, such as schools, and for different levels of ground shaking accompanying moderate to large earthquakes, so that the cost-effectiveness of retrofit options and other loss-reduction measures can be realistically evaluated.

Responsible Agencies

- Utah Seismic Safety Commission
- Utah Division of Comprehensive Emergency Management/Utah Geological Survey/other data providers
- Utah Division of Risk Management/other users of loss estimates
- Structural Engineers Association of Utah

Resources Needed

- Cost to review methods and determine needs: $30,000.
- Cost to apply University of Utah methods: not available at this time.
- Cost to apply ATC-36 methods: not available at this time.
- Cost to apply FEMA/NIBS methods to first earthquake scenario: $250,000.

STRATEGY: Evaluate the indirect losses associated with earthquakes.

OUTPUT: A study assessing the indirect economic losses from earthquakes including: wage and job loss, rebuilding cost, impacts on insurance and financial institutions, and costs of business interruption and failure.

OUTCOME: Identification of indirect economic impacts, resulting in increased preparedness, more rapid recovery, and wise resource allocation.

Background

An earthquake may only last for thirty seconds, but the indirect effects and recovery can last for months or years. The rate of small business failures following an earthquake is high. Also, financial and insurance institutions will incur costs, including disruption of electronic communications and loan/premium payments. Once the costs are known, institutions and businesses can act accordingly in pre-disaster recovery planning.

Implementation

This strategy would be best implemented using the results of a study to estimate the direct losses from an earthquake (see Strategy 5.1). Economists will then be able to estimate indirect losses from direct losses from various scenario earthquakes in various areas. A team of economists will need to be assembled and funding sought to perform the study.

Responsible Agencies
- Utah Seismic Safety Council
- Utah Division of Comprehensive Emergency Management
- Utah Department of Commerce
- Utah Division of Risk Management

Resources Needed
- Cost for study unknown at this time.

STRATEGY: Conduct lifeline collocation vulnerability studies.

OUTPUT: All lifeline collocation sites in UBC seismic zone 3 are identified; a plan is developed for each one.

OUTCOME: During an earthquake emergency, damaged lifelines in one area will not cripple each other.

Background

In many locations, various lifelines, including pipeline, rail, highway, electric, and communications are located within close proximity of each other, either in defined corridors or at crossings. Seismic damage to one lifeline may easily impact adjacent lifelines. The Federal Emergency Management Agency (FEMA) has funded the study of earthquake-induced failure of the concentrated lifelines at the Beck Street overpass area in Salt Lake City; numerous other similar locations exist along the Wasatch Front.

Implementation

Undertake studies to identify all critical collocation sites within UBC seismic zone 3. Establish a task force of public and private sector lifeline operators to evaluate the potential impacts of their facilities from damage to adjacent lifelines.

Responsible Agencies

- Utah Division of Comprehensive Emergency Management
- Utah Department of Transportation
- Municipal and private utilities, railroads, and pipeline operators

Resources Needed

Cost to identify UBC seismic zone 3 collocation sites and perform screening studies to identify potential risks, using existing methods and data: $100,000.

Cost to perform detailed studies depends on number and complexity of sites and quality of existing data.

GLOSSARY OF TERMS

Aftershock—an earthquake that follows a larger earthquake in the same general area. The number and sizes of aftershocks normally decrease over time, but many are capable of causing injury and damage.

Debris Flow—a muddy slurry of water, soil, rock, and organic material much like wet concrete that flows downslope.

Earthquake—the shaking or vibrating of the ground caused by the sudden release of energy stored in rock beneath the earth's surface.

Epicenter—the point on the surface of the earth directly above the focus or hypocenter (origin) of an earthquake. Point directly above where an earthquake originates.

Fault—a fracture in the earth along which the two sides have been displaced relative to one another.

Focus (hypocenter)—the initial point of rupture of an earthquake below the surface; the point within the earth that is the origin of an earthquake.

GPS—"Global Positioning System" technology, based on satellite signals, that allows the horizontal and vertical position of a point on the earth to be measured with a precision as fine as a centimeter or less using portable receivers.

Hazard—any physical phenomenon that has the potential to produce harm or other undesirable consequences to some person or thing.

Landslide—a general term for any type of downslope movement of rock and soil under the influence of gravity.

Lifelines—utility lines used for the distribution and transmission of oil, gas, water, sewer, and telephone and electrical service.

Liquefaction—loss of strength caused when water-saturated, sandy soils react to vibrations and temporarily act like a liquid.

Magnitude—a quantity characteristic of the total energy released by an earthquake. The Richter Scale is commonly used for Utah earthquakes. It is a logarithmic scale based on the motion that would be measured by a standard (Wood-Anderson) type of seismograph, 100 kilometers (60 miles) from the epicenter.

Non Structural—curtain walls, non-bearing partitions, suspended ceilings, water heaters, filing cabinets, etc.

Normal Fault—dipping fault where the upper block drops down relative to the lower block on the other side. Most Utah faults are normal faults.

Real-Time Monitoring—the recording and processing of seismic data in such a way that immediate post-earthquake information is available within minutes to emergency managers. (Standard earthquake-monitoring schemes typically involve a delay of a half-hour to an hour before seismologists can report the location, size, and extent of an earthquake.)

Retrofit—repair, brace, and strengthen buildings and structures to resist seismic forces.

Risk—the probability that the potential harm or undesirable consequences of a hazard will be realized; the combination of the hazard and the vulnerability.

Seismic—pertaining to an earthquake or earth vibration.

Seismograph—an instrument that records waves generated by an earthquake.

Seismogram—a recording of earthquake waves by a seismograph.

Soil-foundation problems—excessive settlement or heave of soil beneath a building, causing damage to the foundation.

Strong-Motion Instrument—a rugged, low-magnification seismograph designed to record the amplitude, frequency, and duration of strong ground shaking that is potentially damaging to structures.

Unreinforced Masonry—buildings or structures built of brick, concrete, and glass block, hollow clay tiles, or stone that are not reinforced with steel mesh or reinforcing bars.

Zone of Deformation—distortion, slumping and cracking of the ground surface (mainly on the valley side) at or very near the line where a fault breaks or intersects the surface.

Vulnerability—susceptibility to physical injury, harm, or damage.

APPENDIX

The Utah Seismic Safety Advisory Council (USSAC) Members, 1977-1981:

Harvey L. Hutchinson	Chairman; Civil Engineer, Utah Water Conservancy District (Utilities)
Stanley W. Crawley	Vice-Chairman; Professor, Graduate School of Architecture, University of Utah (Architecture)
Genevieve Atwood	Representative, Utah Legislature (Public-at-Large)
Jerold H. Barnes	Director, Salt Lake County Planning Department (Planning)
Winfred O. Carter	Professor, Department of Civil Engineering, Utah State University (Engineering)
William J. Gordon	Geotechnical Engineer, Dames & Moore (Geotechnical Engineering)
Bruce N. Kaliser	Engineering Geologist, Utah Geological Survey (Geology)
Harvey W. Merrell	Utah Association of Counties
Joyce U. Miller	Utah League of Cities and Towns
Donald J. Peck	Public-at-Large
Robert B. Smith	Professor, Department of Geology and Geophysics, University of Utah (Seismology)
Delbert B. Ward	Executive Director; Adjunct Associate Professor, Graduate School of Architecture, University of Utah

The Utah Advisory Council for Intergovernmental Relations, Earthquake Task Force Members, 1989-1991:

Ken Alkema	Director, Utah Division of Environmental Health
M. Lee Allison	Director, Utah Geological Survey
Walter J. Arabasz	Director, University of Utah Seismograph Stations
Kenneth Bullock	Executive Director, Utah League of Cities and Towns
Michael Christensen	Deputy Director, Governor's Office of Planning and Budget
Carl Eriksson	Inspection Services Manager, Salt Lake County
Lorayne M. Frank	Director, Utah Division of Comprehensive Emergency Management

Brent Gardner	Executive Director, Utah Association of Counties
Pat Iannone	Utah Association of Realtors
David L. Johnson	Deputy Director, Utah Department of Administrative Services
Kenneth W. Karren	Structural Engineer, Karren and Associates
Jerrianna Kolby	American Red Cross
Dennis Lifferth	Church of Jesus Christ of Latter-Day Saints
Peter W. McDonough	Senior Operations Engineer, Mountain Fuel Supply Company
Kenneth J. Naylor	American Institute of Architects, Utah Chapter
Ray Nielsen	Representative, Utah Legislature
Craig A. Peterson	Senator, Utah Legislature
Lawrence D. Reaveley	Chairman, Utah Geological Survey Board
Carole Scott	Mayor, Town of Manila
Wilford H. Sommerkorn	Assistant Director, Davis County Planning Department
Neal P. Stowe	Director, Utah Division of Facilities Construction and Management
Richard Thorn	Associated General Contractors
T. Leslie Youd	Professor, Department of Civil Engineering, Brigham Young University

The Utah Earthquake Advisory Board (UEAB) Members, 1991-1994:

Lorayne M. Frank	Chairperson; Director, Utah Division of Comprehensive Emergency Management
M. Lee Allison	Director, Utah Geological Survey
Walter J. Arabasz	Director, University of Utah Seismograph Stations
Kenneth Bullock	Executive Director, Utah League of Cities and Towns
David Curtis	Engineer, Curtis Engineering; Structural Engineers Association of Utah
Frank M. Fuller	Project Coordinator, Utah Division of Facilities Construction & Management

James W. Golden	Assistant Chief Structural Engineer, Utah Department of Transportation
Steven M. Klass	Governor's Office of Planning and Budget, 1991-1993 (Assistant State Planning Coordinator)
John A. Harja	Governor's Office of Planning and Budget, 1993-1994 (Senior Research Analyst)
Suzanne Winters	Governor's Office of Planning and Budget, 1994 (State Science Advisor)
Michael Stransky	American Institute of Architects, Utah Chapter, 1991-1993 (Architect, Stransky and Associates)
Barry Smith	American Institute of Architects, Utah Chapter, 1993-1994 (Architect, Astle-Ericson & Associates)
T. Leslie Youd	Civil Engineer, Brigham Young University; American Society of Civil Engineers, Utah Chapter

The Standing Committees of the UEAB, 1993-1994:

Awareness and Education Standing Committee—M. Lee Allison, Chairperson

Kathy Bledsoe	Parent Teacher Association
Rex Curtis	Retired School Teacher
Steve Lutz	Director, State Fire Academy
Gary Madsen	Associate Professor, Department of Sociology, Utah State University
Hollie Muir	Disaster Education Coordinator, American Red Cross
DeeDee O'Brien	Outreach Coordinator, College of Mines and Earth Sciences, University of Utah
Patrick Reese	Emergency Response, Church of Jesus Christ of Latter-Day Saints
Kay Sadler	MIS Director, West Valley City
Kimm Williams	Public Information Officer, Utah Division of Comprehensive Emergency Management

Engineering and Architecture Standing Committee—David Curtis, Chairperson

Carl Carpenter	Principal Engineer, Provo City Water Resources Department
Scott Ellis	Structural Engineer, Ellis and Associates
Frank M. Fuller	Project Coordinator, Utah Division of Facilities Construction & Management
James W. Golden	Assistant Chief Structural Engineer, Utah Department of Transportation

Peter W. McDonough	Senior Operations Engineer, Mountain Fuel Supply Company
Barry Smith	Architect, Astle-Erickson & Associates
Michael Stransky	Architect, Stransky and Associates

Geoscience Standing Committee—Walter J. Arabasz, Chairperson

M. Lee Allison	Director, Utah Geological Survey
Jeffrey R. Keaton	Senior Engineering Geologist and Vice President, AGRA E and E, Inc.
William R. Lund	Deputy Director, Utah Geological Survey
James C. Pechmann	Research Associate Professor, Department of Geology and Geophysics, University of Utah
Kyle M. Rollins	Assistant Professor, Department of Civil Engineering, Brigham Young University
T. Leslie Youd	Professor, Department of Civil Engineering, Brigham Young University

Response and Recovery Standing Committee—Lorayne M. Frank, Chairperson

Roger Anderson	Assistant Director, Davis County Emergency Services
Roger Forsberg	Manager of Performance Management, Thiokol Corporation
LeGrand Jones	Loss Control Administrator, Utah Department of Transportation
Deborah H. Kim	Emergency Services & Trauma Coordinator, University of Utah Medical Center
Jeff Rylee	Director, Salt Lake City Emergency Services

The Utah Seismic Safety Commission (USSC) Members, 1994:

T. Leslie Youd	Chairperson; Department of Civil Engineering, Brigham Young University; American Society of Civil Engineers, Utah Chapter
Craig A. Peterson	Senator, Utah Legislature
Clark Reber	Representative, Utah Legislature
D. Douglas Bodrero	Commissioner, Utah Department of Public Safety
M. Lee Allison	Director, Utah Geological Survey

Walter J. Arabasz	Director, University of Utah Seismograph Stations
James Bailey	Structural Engineer, Allen & Bailey Engineers; Structural Engineers Association of Utah
Kenneth Bullock	Executive Director, Utah League of Cities and Towns
Lorayne M. Frank	Director, Utah Division of Comprehensive Emergency Management
James W. Golden	Assistant Chief Structural Engineer, Utah Department of Transportation
William E. Juszcak	Project Coordinator, Utah Division of Facilities Construction & Management
Barry Smith	Architect, Astle-Ericson & Associates; American Institute of Architects, Utah Chapter
Suzanne Winters	State Science Advisor, Governor's Office of Planning & Budget

For More Information Contact the Following:

For questions about earthquake preparedness—

The Utah Division of Comprehensive Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114
(801) 538-3400

For questions about geology, faulting, and natural hazards in Utah—

Utah Geological Survey
2363 South Foothill Drive
Salt Lake City, Utah 84109-1497
(801) 467-7970

For questions about earthquake monitoring and research—

University of Utah Seismograph Stations
705 William C. Browning Building
Salt Lake City, Utah 84112-1183
(801) 581-6274

For general geologic information—

U.S. Geological Survey
Earth Science Information Center
2222 W. 2300 South
Salt Lake City, Utah 84119
(801) 975-3742

For emergency services information—

American Red Cross
1391 South Park Street
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Salt Lake City, Utah 84152-6279
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EARTHQUAKE SAFETY IN UTAH

USSC

DECEMBER 2000

A Progress Report on the Activities and Accomplishments of the

UTAH SEISMIC SAFETY COMMISSION

for the Period July 1, 1996 to June 30, 2000

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Utah Seismic Safety Commission, December 2000

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Commission Chair
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Representative Don Bush
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Vanna Hunter
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Senator Peter C. Knudson
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Earl Morris
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Barry Smith
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Representing the State Planning Coordinator

Former Commission Members During July 1996-June 2000

M. Lee Allison, 1994-1999
Utah Geological Survey

James S. Bailey, 1994-2000
Structural Engineers Association of Utah

Dan Bauer, 1998-2000
Representing the State Planning Coordinator

Commissioner D. Douglas Bodrero, 1994-1997
Department of Public Safety

Kenneth H. Bullock, 1994-1999
Utah League of Cities and Towns

Commisioner Craig L. Dearden, 1997-2000
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James W. Golden, 1994-1999
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William E. Juszcak, 1994-1998
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Janine Jarva, 1994-1998
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Barry Solomon, 1997-2000

Acknowledgments

The Commission is greatly indebted to its staff and to the many members of its various committees, identified in Appendix A, for both past and ongoing efforts in helping to advance earthquake safety in Utah. We give special thanks to Tim Madden for his assistance in compiling and editing an earlier draft version of this report, which included many of the descriptions of the activities and accomplishments of the Commission and most of the survey of seismic safety initiatives summarized in Appendices E, F, and G. We also thank the many respondents to surveys described in this report relating to: (1) earthquake preparedness in schools, (2) earthquake safety awareness in businesses and communities, and (3) lifeline inventories.

CONTENTS

FOREWORD

We know for certain that Utah's people, built environment, and economy are all exposed to a real and constant earthquake threat. Most Utahns view earthquake dangers as more unlikely than they truly are, and risk—the likelihood of loss—is increasing because of dramatic population and urban growth in earthquake-prone areas like the Wasatch Front.

A report issued in September 2000 by FEMA, the Federal Emergency Management Agency, called *HAZUS99 Estimated Annualized Earthquake Losses for the United States,* helps to place Utah's earthquake risk in perspective. According to the report, projections of direct economic losses in Utah to the building stock alone (damage repair, rebuilding, loss of contents and use)—factoring in both infrequent large earthquakes and more frequent moderate-size shocks—add up to **$51.5 million per year** on an annualized basis. Like an actuarial statistic, this is the loss that is expected, averaged over time.

The FEMA report ranks Utah **seventh** in the Nation in absolute risk and **sixth** in relative risk when one takes the ratio of the average annualized earthquake loss to the replacement value of the building inventory. The report emphasizes that the loss estimates are extremely conservative because they do not cover damage and losses to critical facilities, transportation systems, and utility lifelines—nor indirect economic losses (ripple effects on economic sectors that do not sustain direct damage).

What about losses in a single big quake? A study reported in 1997 by the Applied Technology Council in California estimates that the expected direct economic losses to buildings and lifelines for a magnitude 7.5 earthquake in Salt Lake County would be approximately **$12 (±3) billion**. If one adds indirect economic and social losses (casualties, displaced households, and short-term shelter needs), total losses could be 20 percent higher, putting the total in the range of $11 billion to $18 billion.

Will such a "big one" happen in our lifetime? Geologists debate whether the chance of a big quake on the Wasatch fault in the Salt Lake Valley in the next 50 years is closer to 5 percent or 25 percent. In either case, it's clear that we're playing Russian roulette with stored-up earthquake energy on the Wasatch fault—and other active faults—in Utah.

During the past 5600 years, large earthquakes have occurred on the Wasatch fault's Salt Lake City segment about once every 1400 years, and the last one was almost that long ago. The Wasatch fault has unleashed a magnitude-7-size shock along one or another of its five segments between Brigham City and Nephi every 350 years on average in the past 5600 years. The last one happened about 600 years ago near Provo.

Utah is not as prepared as it needs to be to withstand, respond to, and recover from future earthquakes—including damaging, moderate-size shocks in the magnitude 5 and 6 range. Since the 1950s, shocks of this size have occurred in the Utah region one to three times every decade, and growth is increasing the odds that populated areas will be hit.

The mission of the Utah Seismic Safety Commission is to improve earthquake safety in Utah—to save lives, prevent injuries, protect property and the environment, and reduce social and economic disruption from earthquakes. Individuals and communities don't have to be at the complete mercy of earthquake forces. We **can** have some control, and we **can** reduce earthquake losses.

Lessons learned from earthquake disasters around the world point the way to improving earthquake safety in Utah:

- ♦ heightened public awareness and consumer demand for earthquake safety
- ♦ better building codes and enforcement
- ♦ strengthening of vulnerable buildings
- ♦ prudent urban planning and development
- ♦ improved design and protection of critical infrastructure
- ♦ better tools and readiness for emergency response and recovery
- ♦ better information on geological hazards and their effects, especially in urban areas
- ♦ and the joint commitment and leveraging of public and private funding to achieve the above

This progress report on the activities and accomplishments of the Utah Seismic Safety Commission during 1996-2000 includes many successes. What has worked best for the Commission has been an ongoing response to its statutory charge to "act as a source of information for individuals and groups concerned with earthquake safety and as a promoter of earthquake loss reduction measures."

We've taken most of the easy steps towards earthquake preparedness that require only modest resources. There remains the challenge of taking key long-term defensive actions that will require larger funding in the range of hundreds of thousands to millions of dollars. The willingness of the public and private sectors in Utah to make such investments ought to be guided by sensible principles of risk management—as was the praiseworthy decision to use high seismic design standards in rebuilding I-15.

Faced with the projection of annualized earthquake losses of $51.5 million per year, or with the prospect of losses of $11 billion to $18 billion from a single large earthquake on the Wasatch fault, decision-makers in Utah must deal with this risk in informed realistic ways.

For our part, we on the Utah Seismic Safety Commission are keenly aware of the dangerous mix in the Wasatch Front area of (1) dramatically increasing population,
(2) complex and costly urban infrastructure, and (3) pent-up earthquake energy. And we are equally aware that earthquakes in Utah are not just a Wasatch Front problem.

We pledge to continue our efforts to advance earthquake safety in Utah—and we look forward to a continuing partnership with public and private leaders to reduce the impact of future earthquakes on people, homes, businesses, and communities in Utah.

Walter J. Arabasz
Chair, Utah Seismic Safety Commission

EXECUTIVE SUMMARY

Since 1995 when the Commission created *A Strategic Plan for Earthquake Safety in Utah*, 27 (or three-fourths) of its 35 strategic objectives have either been successfully met or are being addressed in an ongoing way. This report describes varied activities and accomplishments of the Commission—either initiated, planned and executed, influenced, or engaged in—during the four-year period from July 1996 through June 2000. An earlier progress report for the period from July 1994, when the Commission was formed, through June 1996 was issued in November 1996.

This report also details the results of a survey on earthquake awareness issues. The survey, which supplements an earlier survey summarized in the 1996 progress report, was sent to counties, cities, and major employers throughout the state. The latest survey was intended to gather information on earthquake-related regulations, enforcement activities, reviews, educational practices, and mitigation efforts in Utah by private and governmental entities, and to evaluate the level of commitment those entities place on earthquake safety. Generally speaking, the survey shows that the larger the entity, public or private, the higher the priority given to earthquake safety.

The USSC maintains five Standing Committees, greatly enlarging the number of individuals actively involved in carrying out the work of the Commission. These committees respectively focus on (1) Awareness and Education (incorporating an earlier separate committee on Emergency Management), (2) Engineering and Architecture, (3) Geoscience, (4) Lifelines and Infrastructure, and (5) Intergovernmental Relations. The Commission also depends heavily upon the Utah Division of Comprehensive Emergency Management, the Utah Geological Survey, and the University of Utah Seismograph Stations—three key partners in Utah's state earthquake program—to pursue the Commission's goals.

Some of the notable activities and accomplishments of the Commission during the report period, organized under nineteen topical issues and actions, include the following:

- **Seismic safety in school construction:** Beginning in 1997, advocacy by the Engineering and Architecture Committee—and consensus-building with school districts—resulted in the adoption of regulations by the State Board of Education in 1999 that require all new school construction (and major additions to existing facilities) in regions of moderate to high seismic risk to undergo seismic quality control reviews by a licensed structural engineer.

- **Prepared schools:** The Schools Subcommittee of the Awareness and Education Committee gained the cooperation of school administrators, teachers, and parents in helping prepare K-12 schools for earthquakes and other disasters. A 1998 survey of emergency preparedness sent to 731 public schools (50 percent response) and 102 private schools (25 percent response) has formed the basis of an ongoing "Prepared Schools Project" under which schools can qualify for reduced insurance premiums. The Schools Subcommittee received a national award in excellence for educational outreach to schools for its project, “Prepared Schools for Effective Drills and Safe Surroundings.”

- **Involving businesses and institutions in seismic safety planning:** The Awareness and Education Committee planned and convened three conferences—in 1996, 1997, and 1998—to motivate businesses and institutions to include earthquake safety in their contingency planning and to help businesses survive and recover from earthquakes. The conferences successfully attracted more than 500 participants, received prominent newspaper and TV media coverage, distributed volumes of reference material and self-help guides, and raised public awareness of practical steps that can increase earthquake safety and economic survival.

- **Recognizing efforts of businesses, governments, schools, and individuals to improve seismic safety in Utah:** In 1996 and 1997 the Commission publicly recognized and made awards for excellence and outstanding contributions to earthquake safety in Utah. In 1996 the Award for Outstanding Contributions to Earthquake Saftey in Utah went to the *Salt Lake Tribune* and its science writer, Lee Siegel (for informative reporting on many earthquake-related issues in Utah); in 1997, to Mountain Fuel Supply Company (for seismic strengthening of its facilities and varied efforts in earthquake awareness). Certificates of Excellence were awarded in 1996 to Brigham Young University (for campus- and community-wide safety efforts), the Salt Lake City School District (for pioneering efforts in seismically strengthening local schools), and Hyde Park City (for diverse community actions in earthquake preparedness); in 1997, to the Utah Department of Transportation (for state-of-the-art seismic design in the Interstate 15 reconstruction project).

- **Recognition of efforts by Commission staff to advance earthquake education and awareness:** Three public-education projects undertaken in coordination with the Commission received awards in excellence in 1997 from the Western States Seismic Policy Council. These involved (1) providing earthquake-related curriculum material and training to teachers in Utah schools together with developing and circulating a traveling exhibit on *Earthquakes in the Intermountain West*, (2) publishing *The Utah Guide for the Seismic Improvement of Unreinforced Masonry Buildings*, and (3) producing a series of maps and brochures that describe earthquake hazards and risk in Utah.

- **Building code enforcement and plan review:** In 1996 the Engineering and Architecture Committee prepared a White Paper on building-code enforcement and plan review recommending amendments to state law that would ensure code enforcement and provide for licensing or certification of building officials and plans examiners throughout the state. Draft legislation based on these recommendation failed in the Utah legislature in 1997. There have been ongoing efforts to effect rules changes through the Utah Division of Professional Licensing.

- **Seismic strengthening of existing buildings:** Since April 1999 the Commission has been (1) actively advocating seismic upgrading of unreinforced masonry buildings when their lives are extended through major remodeling and (2) enforcement of an existing statewide ordinance that requires building owners to install roof anchors and parapet bracing when reroofing their buildings. These efforts involve partnering with the Structural Engineers Association of Utah and the Uniform Building Code Commission.

- **Seismic vulnerability of state buildings:** In 1996 the Commission attempted unsuccessfully to advocate dedicated state funding for progressively remediating the seismic vulnerability of older state-owned buildings. In October 1999, Commissioner Matthias Mueller of the Division of Facilities Contruction and Management outlined results of a survey of 193 older state buildings indicating that 111 of the 193 buildings surveyed by that date needed structural upgrading. Progress is being incrementally made in seismically strengthening selected state-owned buildings as part of major remodeling projects.

- **The safety of construction in downtown Salt Lake City:** In 1998 and 1999 the Commission served as a sounding board and forum for concerns about fault-displacement hazards associated with active faults in the Salt Lake City metropolitan area. The public discussions related to (1) active-fault maps and geotechnical reports required for building permits and (2) whether an active fault is under the site of an expansion to the Salt Palace. Some issues for earthquake-hazard ordinances in Salt Lake County remain unresolved. For the Salt Palace construction, both Salt Lake County and Salt Lake City accepted a finding that geological features uncovered in the Salt Palace excavation were liquefaction-induced and not directly associated with an active fault.

- **Vulnerability of the state's lifelines, infrastructure, and water and wastewater systems:** Since 1998 the Lifelines and Infrastructure Committee has been involved in an ongoing project to create a GIS-based inventory of all the important lifelines in Utah, including transportation routes and utility corridors, with a primary focus on the Wasatch Front area. The Commission sponsored educational presentations to operators of water and wastewater systems in Utah to help them evaluate the seismic vulnerability of their own systems. The Commission is also partnering with other state groups to make Utah's critical infrastructure disaster-resistant.

- **Interstates 15 and 80 bridge reconstruction:** In 1996, four members of the Commission's Geoscience Committee served on an I-15 Corridor Seismic Advisory Committee to assist the Utah Department of Transportation (UDOT) in establishing seismic design criteria and in reviewing and making recommendations on the acceptability of earthquake-related studies and design recommendations made by I-15 consultants. The committee persuaded UDOT to use design standards for I-15 that were higher than those it conventionally uses so that freeway bridges would not collapse but at most sustain reparable damage during a large earthquake on the Wasatch fault. UDOT is also attending to reinforcement of aging highway bridges on I-80 between State Street and Parley's Canyon in the Salt Lake Valley.

- **Local government needs for geoscience information and training to reduce risks from earthquakes and other geologic hazards:** In 1999 the Geoscience Committee and the Utah Geological Survey jointly established a Guidelines Advisory Committee to work with local governments to determine what information products and services relating to geologic hazards were needed, who should provide them, and what resources were needed. A final report was completed in late 1999. The committee addressed the possible roles of local government insurers—Utah Risk Management Mutual Agency and Utah Local Governments Trust (UGLT)—in encouraging risk reduction.

- **Recognizing earthquake hazards, assessing risks for communities, and preparing communities for emergency response:** Since 1997 the Utah Division of Comprehensive Emergency Management, together with the Commission's Emergency Management Committee, has been involved in (1) implementing Hazards United States (HAZUS), a geographic information system-based software package that identifies earthquake hazards and assesses the loss-vulnerability of communities and (2) providing Community Emergency Response Team (CERT) training. Both projects are greatly advancing earthquake preparedness in Utah.

- **Real-time earthquake information system and strong-motion recording:** Initiatives aimed at strong-motion instrumentation and real-time earthquake information capabilities have long involved scientists and engineers from the University of Utah Seismograph Stations (UUSS), the Utah Geological Survey, and the Commission. Efforts finally bore fruit in 1999 with the announcement that UUSS would receive federal funding during fiscal year 2000 under a cooperative project with the U.S. Geological Survey to begin building a real-time urban strong-motion network in the Ogden-Salt Lake City-Provo urban corridor before the 2002 Winter Olympics. The system will rapidly provide automatically-generated earthquake alerts and computer maps of the intensity and extent of strong ground shaking within minutes of a sizable local earthquake.

- **A Unified Utah Earthquake Master Model:** In 1997 the Commission and its Geoscience Committee deliberated on new information and an action proposal for "A Unified Utah Earthquake Master Model" from Professor Robert Smith, University of Utah, relating to deformation measurements across the Wasatch fault from Global Positioning System (GPS) monitoring. While the Commission has adopted a cautious approach to interpreting higher-than-expected rates of deformation reported from the GPS monitoring, Professor Smith continues to provide a valuable service in developing and operating arrays of GPS instruments for continued monitoring of earth deformation in Utah.

- **National Science Foundation request for proposals to fund earthquake engineering centers:** In 1996 the Commission voted unanimously to support a competitive proposal to the NSF from a consortium—including Brigham Young University, Utah State University, the University of Utah, Portland State University, the Oregon Department of Mineral Industries, and the Utah Geological Survey—to develop an earthquake-engineering research center in Utah. In April 1997, after the proposal had been submitted, NSF revised the program announcement and ultimately funded centers in California, New York, and Illinois.

- **The relevance of Seismic Safety Commissions:** In 1999 an invited presentation by the chair of the Nevada Earthquake Safety Council inspired the Commission (1) to seek an amendment to the Utah Seismic Safety Commission Act of 1994 that would allow the USSC to solicit and receive external funding and (2) to pursue more aggressively better building codes and their enforcement for earthquake safety. The Utah Seismic Safety Commission Act was successfully amended in the 2000 general session of the Legislature, and the Engineering and Architecture Committee—jointly with the Structural Engineers Association of Utah—began to champion the seismic strengthening of existing buildings.

- **Disaster-resistant communities:** The dramatic growth and development in Utah's Greater Wasatch Area increases the urgency of taking actions that will make Utah's communities more disaster resistant. Funding from the Federal Emergency Management Agency under *Project Impact* to selected cities (Centerville, Salt Lake City, Logan, Moab, Provo) is advancing this goal.

- **Commission Meetings Outside the Salt Lake City Area:** Quarterly meetings of the Commission outside the Salt Lake City metropolitan area have become a valuable outreach tactic to promote earthquake awareness and planning. In April 1998 the Commission met in Brigham City with the public and with officials from Box Elder, Cache, and Weber Counties. In April 2000 the Commission similarly traveled to the campus of Brigham Young University in Provo to meet with local and county officials in Utah County. [In April 2001 the Commission will meet in Ogden.]

The Commission's priorities for the future include: expanding its "Prepared Schools" program; advocating requirements for strengthening older existing buildings; improving the survivability and post-earthquake usability of essential service buildings; evaluating the seismic vulnerability of Utah's lifelines; ensuring that geologic-hazards investigations are performed for the safe siting of all new schools and critical public facilities; assisting local governments to reduce risks from earthquakes and other geologic hazards; supporting continued development of urban strong-motion monitoring and a real-time earthquake information system in the Wasatch Front area; ensuring that design professionals and building officials are kept current on relevant geoscience information; and advocating the disclosure of known geologic hazards in real-estate transactions so that homebuyers are appropriately informed of the risk they are assuming.

INTRODUCTION

In 1994 the Utah State Legislature created the Utah Seismic Safety Commission (USSC) with the explicit charge (see Appendix B) to do the following:

(a) review earthquake-related hazards and risks to the state of Utah and its inhabitants;
(b) prepare recommendations to identify and mitigate these hazards and risks;
(c) prioritize recommendations and present them to state and local governments or other appropriate entities for adoption as policy or loss reduction strategies;
(d) act as a source of information for individuals and groups concerned with earthquake safety and as a promoter of earthquake loss reduction measures;
(e) prepare a strategic seismic planning document to be presented to the State and Local Interim Committee before the 1995 general session of the legislature; and
(f) periodically update the planning document and monitor progress towards achieving the goal of loss reduction.

The mission of the Utah Seismic Safety Commission is to improve earthquake safety in Utah—to save lives, prevent injuries, protect property and the environment, and reduce social and economic disruption from earthquakes. The Commission's 1995 *A Strategic Plan for Earthquake Safety in Utah*, which has provided an effective "road map" for action (see Appendix C), set out the following guiding principles:

1. There is a real and serious danger of both life-threatening and damaging earthquakes in Utah in our lifetimes.

2. We as individuals and collectively can take significant actions now to reduce the loss of life, property damage, and long-term economic impact in the future.

3. Implementing an earthquake-safety plan for Utah is a long-term process.

4. Strategies to safeguard lives and property from earthquakes must be sensitive to financial and regulatory burdens. Many actions can be taken now without great expense that will make Utah safer tomorrow.

Earthquakes can't be prevented, but human behavior and the built environment can be modified to mitigate the impact of such events. As recent victims in earthquake-ravaged regions of Turkey, China, Taiwan, Japan, and the United States can attest, preparedness is important and can pay dividends.

One of the significant accomplishments of the Commission has been to provide leadership and coherence to Utah's state earthquake program. Besides the Commission's 15 members, Commission activities actively involve, on an ongoing basis, more than 35 interested individuals on five standing committees (Appendix A): Awareness and Education, Engineering and Architecture, Geoscience, Lifelines and Infrastructure, and Intergovernmental Relations.

The Commission has been particularly successful in meeting its charge to “act as a source of information for individuals and groups concerned with earthquake safety and as a promoter of earthquake loss reduction measures.” Successes in promoting earthquake awareness and loss-reduction actions have notably come from media attention to issues raised at quarterly meetings (including meetings at sites outside of Salt Lake City), focused activities of the standing committees, and Commission sponsorship or co-sponsorship of special-topic conferences.

In the main body of this report, we describe specific activities and accomplishments of the Commission during the four-year period, July 1996 through June 2000. Instead of a chronological recital, they are organized under key issues and actions.

Separately, in Appendix E, we describe and discuss a survey sent to (a) 52 of the state’s largest employers, (b) all 29 counties, and (c) 112 first-, second-, and third-class cities. The survey examines how counties, communities, and businesses in Utah view their level of awareness of earthquake safety and the priority they place on earthquake safety, given the relative seismic risk where they are located.

Finally, taking into account the results of the survey described in Appendix E, we outline our plans for future initiatives, priorities, and activities for the Commission.

KEY ISSUES AND ACTIONS

SEISMIC SAFETY IN SCHOOL CONSTRUCTION

STRATEGIES ADDRESSED

3.1 — Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.

ACTION

At its second quarterly meeting of 1997, the Commission heard from the Engineering and Architecture Standing Committee (EASC) on proposed legislation that would have required state licensing of building-plans examiners. As an illustration of the problems inherent in the existing system, the EASC said no more than 10 percent of the 40 school districts in the state use licensed building inspectors, whose primary responsibility is to make sure the construction is being done according to the plans, not if the structure complies with building codes generally or seismic-safety requirements specifically.

When the report was published in a daily newspaper, the reaction from school districts was immediate. A contingent from the four largest districts in Utah asked to be allowed to respond at the next quarterly meeting of the Commission, on July 2, 1997. A spirited discussion ensued, with the school officials maintaining that their process adequately addressed the concerns of seismic safety. The Commission proposed that the EASC specifically and the Commission in general participate in a continuing dialogue with school districts to find out whether current practices of design, plan-checking, and inspection of new school construction in Utah posed an earthquake-safety issue. The intended outcome of this voluntary discussion would be to determine whether there is a process in place to ensure safe schools in Utah and, on a larger scale, whether there is concern for the structural safety of all buildings in Utah.

At the fourth quarterly meeting of the year, the EASC reported back that (1) the larger issue of building safety throughout Utah was an ongoing concern and (2) there was a need to review school construction designs later in the design process than is currently being done. The latter issue was to be directed to the State Office of Education to resolve through administrative rulemaking rather than attempt to accomplish any sort of legislative mandate.

At the second quarterly meeting of 1998, the EASC reported on a meeting with the State Superintendent of Public Education regarding the issue of “improved plan review” for school construction within the State of Utah. The Superintendent encouraged the EASC to submit written recommendations for consideration by his office.

By October 1998, a proposal which had been reviewed by representatives from the Granite, Davis, and Salt Lake school districts was submitted by the EASC to the State Office of Education. The proposal called for additional structural review by a licensed structural engineer at the 90-percent completion phase of design for new school construction. As a means of reducing the costs and the time involvement for this second review, it was proposed that it be performed by the same structural engineer who took part in an early-stage "value engineering session."

OUTCOME

The State Board of Education (SBE) adopted Rule R277-471, "Oversight of School Inspections," in the summer of 1999. The rule became effective November 2, 1999, and has the same authority as statute. At the same time, the State Office of Education (SOE) published the "School Building Construction and Inspection Resource Manual," and the new Rule specifies that the SBE, local school boards, and school district personnel shall act consistent with the Manual.

The Manual stipulates that a licensed structural engineer shall perform a value-engineering review of school plans and specifications at the 90-percent completion stage in buildings where costs exceed $300,000. The review "will focus primarily on the lateral load resisting systems and details."

The SOE requires that all new school construction and major additions to existing facilities located in regions of moderate to high seismic risk (Zones 2B and 3) be subject to this procedure.

PREPARED SCHOOLS

STRATEGIES ADDRESSED

1.1 — Inform citizens about earthquake hazards and risks.
1.2 — Incorporate earthquake education in school curricula.
3.3 — Improve the post-earthquake operational status of essential service buildings.
3.6 — Improve safety and operation ability of older public school buildings.
5.1 — Update estimates of direct losses to be expected from earthquakes.
5.2 — Evaluate the indirect losses associated with earthquakes.

ACTION

The Awareness and Education Standing Committee (AESC), through its Schools Subcommittee, undertook a survey of public and private schools in Utah. The survey was mailed in April 1998 to 731 public school and 102 private school principals. Of that total, 365 public schools (49.9 percent) and 25 private schools (24.5 percent) responded. The purpose of the survey was to learn what has already been done in schools to prepare for emergencies and in what areas help is needed to become better prepared. During the course of the survey, the AESC's School Subcommittee succeeded in gaining Governor Mike Leavitt's endorsement on a proclamation designating April as "Earthquake/Disaster Preparedness Month," which enhanced public awareness of earthquake safety issues.

The responses to the survey indicated that the majority of Utah school principals, both public and private, have an interest in being well prepared for emergencies. Most (94 percent public, 76 percent private) have written plans and all responding schools hold at least one fire drill annually; most (83 percent public, 76 percent private) hold earthquake drills at least once a year, and fewer (50 percent public, 38 percent private) hold drills for other emergencies at least once a year. Even fewer (48.2 percent public, 40 percent private) have ever evaluated their plans, although most (87.4 percent public, 72 percent private) review it at least once every one-to-three years.

When asked specifically about earthquake risk, the respondents produced fewer positive responses. While most schools identified some or all of the nonstructural hazards, such as furnishings that could fall (77 percent public, 92 percent private), far fewer have in place a plan to mitigate these same hazards (59 percent public, 64 percent private). Many of the responding principals did not know whether their buildings had been inspected by structural engineers for earthquake resistance (64 percent public, 48 percent private).

Public schools usually have Parent-Teacher Associations that are active in safety issues (76 percent), and about half of all responding schools recognized that they could use some help in becoming better prepared. Most wanted help with writing emergency plans (52.5 percent public, 50 percent private) and receiving grade-level specific activity packets (57.2 percent public, 75 percent private). Fewer than half wanted how-to workshops on writing plans, conducting drills and exercises, educating school communities, and identifying and mitigating non-structural hazards (43.1 percent public, 41.6 percent private); or CERT training (45 percent public, 37.5 percent private).

A major concern of the survey was with the preparedness of schools that did not reply. Were they statistically similar to the respondents, or did they choose not to participate in the survey because they had very little — or no — interest in earthquake preparedness issues?

The AESC is now using the school surveys to develop a "Prepared Schools Project," a plan to encourage and aid all schools to become better prepared for emergencies in general and earthquake hazards in particular. The project takes schools incrementally through two levels of preparedness, helping them reach the highest standard of readiness.

To assist schools with the "Prepared Schools Project", the AESC developed a "Certificate for Effective Drills and Safe Surroundings," which requires schools to complete four simple tasks: (1) conduct a school-wide earthquake/disaster drill, (2) have the school safety committee evaluate the drill, (3) conduct a school-wide hazard hunt, and (4) conduct the required number of fire drills during the school year. To assist with these tasks, the AESC provided all schools with a binder of activities, curriculum materials, a disaster video, maps, and posters. Once they earn that certificate, schools will then need to demonstrate competency in five areas: (1) awareness and education, (2) reducing risks before the event, (3) emergency response, (4) longer-term emergency response, and (5) recovery.

Another step in preparing schools was the School Safety Plan Bill passed during the 2000 Legislative Session. The Bill, H.B.14, sponsored by Representative Patrice Arent, requires schools to have a comprehensive plan as it relates to school violence. However, most school administrators are taking this opportunity to develop all-hazards school safety plans.

One of the obstacles to the program, according to school administrators, is accomplishing those tasks without detracting from budgeted time for instruction and activities. An example of how schools can make earthquake safety part of the learning curriculum was demonstrated in 1999 by Pleasant Grove High School (PGHS) in Utah County. Administrators used the existing Schools-to-Careers Program at PGHS to stage an earthquake preparedness drill that involved the entire 1,500-person student body, which was able to work with professionals from the local hospital and fire department, police and sheriff's agencies, ambulance companies, local government, newspapers, and radio stations.

As an added bonus, students in the Health Education Academy Program gained experience in triage efforts and first aid, while students in the Drama Department used their make-up skills to make the "injured" students looked realistic. Everybody had a role, and the school even used the drill to have the school district evaluate the building itself, which was constructed in 1959.

PGHS has an evacuation plan in place, and the exercise tested it as well as showing school officials how their plan interfaced with plans of local hospitals, city and county governments, and police agencies. The drill tested evacuation and transportation capabilities by using ambulance companies, school buses, and even Utah Army National Guard paramedic vehicles.

By using a concept known as "job shadowing," administrators were able to keep everybody interested. Students followed health-care providers, police officers, reporters, emergency medical technicians, and fire department personnel as they did their jobs in a stressful setting. The drill involved surrounding communities and, as a part of the curriculum, it can be refined and reused every year.

The School Subcommittee was recognized by the Western States Seismic Policy Council at the National Earthquake Risk Management Conference. The Subcommittee tied with the Washington Division of Emergency Management and the Nevada Seismological Laboratory for the National Award in Excellence for Educational Outreach to Schools.

OUTCOME

By emphasizing the need and demonstrating ways for schools to adapt their curricula to accommodate seismic safety, the Commission has made a real impact on parents, teachers, and school administrators by instilling awareness of an issue too easily overlooked. Tangible outcomes will begin to accrue when schools pass the requirements to become "Prepared Schools" and qualify for reductions in insurance premiums.

INVOLVING BUSINESSES AND INSTITUTIONS IN SEISMIC SAFETY PLANNING

STRATEGY ADDRESSED

1.1 — Inform citizens about earthquake hazards and risks.

ACTION

The Awareness and Education Standing Committee (AESC) planned and convened three conferences—in 1996, 1997, and 1998—as part of a strategic initiative to get businesses and institutions to more carefully consider seismic safety issues in their contingency planning efforts.

At the first conference, “Earthquakes in Utah: Will Your Business Survive?” the AESC made the Strategic Plan an integral part of the agenda. The conference attracted more than 200 participants to the State Office Building and presented Utah business people with the sobering realities of earthquake vulnerabilities.

The conference featured a scenario presentation and panel discussion on what would happen if a magnitude 6.7 earthquake struck Salt Lake City. Representatives from county government, emergency response agencies, insurance and financial institutions, engineering and construction industries, and public utilities discussed possible ways the earthquake would affect them the day of the event as well as one week, one month, and one year later. The conference-goers were left with an encouraging message: preparation saves lives, jobs, and businesses.

Breakout sessions focused on mitigation, emergency response, business recovery, and workplace and home preparedness. Attendees viewed video footage of earthquake damage resulting from the 1994 Northridge, California, event; heard detailed information on building construction for earthquake safety; received tips on how large and small companies address earthquake problems; and picked up tips on making their homes earthquake safe.

The conference concluded with a presentation of the USSC Strategic Plan and the reminder that motivation for improving earthquake safety usually comes from private groups and local governments.

The AESC followed up a year later with another successful conference, “Earthquakes: Mean Business.” The emphasis for this conference was on business survivability issues, and the 1994 Northridge, California, earthquake served as a model for a team of researchers who interviewed business owners one and two years after the event. Business representatives discussed the components of a recovery plan, including the ability to:

- Respond to the new market dynamic by changing strategy and tactics, while being realistic in assessing capabilities and options. If a new location is needed, for example, do it without delay and get the word out; do not simply wait for customers to return.
- Maintain adequate cash reserves and insurance to cover potential damage.

- Know the terms of the lease and the responsibilities contained in it.
- Prepare for recovery delays; it takes time to restore infrastructure and community services.
- Take the extra steps needed to protect business records, both paper and electronic copy.

The message to businesses was clear: think about more than just bricks and mortar. For businesses to survive an earthquake, structural mitigation efforts must be met with management mitigation techniques.

The 1997 symposium also offered breakout sessions on the "employee lifeguard" program for remaining in business in spite of an earthquake, legal liability and insurance issues for employers, business and home preparedness measures, emergency response training, and workplace preparedness and survival techniques. More than 150 business leaders and government officials from the Wasatch Front attended.

In 1998, the AESC joined with the Utah Chapter of the Association of Contingency Planners (ACP) in sponsoring a symposium on preparing businesses and communities for surviving disasters. Presentations included breakout sessions on "How to Plan: The ABCs of Business Resumption Planning," "Plan Validation: Testing Your Plan in Small-Group Table-Top Demonstrations," and "All Hazards Preparation: A Broad-Scope Workshop on All Manner of Perils that can Affect Your Community." This conference attracted about 175 risk managers, contingency planners, and emergency preparedness officials from throughout the state.

Recognizing the value of an ongoing partnership with the Utah Chapter of the ACP, which has many active members from the business sector and major institutions, efforts were made by the Commission, beginning in late 1999, to add a representative from ACP as a formal member of the Commission.

<u>OUTCOME</u>

The three earthquake-awareness conferences attracted more than 500 representatives from communities, businesses, and institutions; received prominent coverage in Salt Lake City's major daily newspapers and television news stations; disseminated volumes of reference material and self-help guides; and helped raise the public's awareness of seismic safety concepts, concerns, and solutions.

Under an amendment to the Utah Seismic Safety Commission Act, passed in the 2000 General Session of the Legislature (see Appendix B), a representative from the Utah Chapter of the Association of Contingency Planners, biannually selected by its membership, was added to the Commission.

RECOGNIZING EFFORTS OF BUSINESSES, GOVERNMENTS, SCHOOLS, AND INDIVIDUALS TO IMPROVE SEISMIC SAFETY IN UTAH

STRATEGIES ADDRESSED

1.1 — Inform citizens about earthquake hazards and risks.

ACTION

During the earthquake awareness conferences that the Awareness and Education Standing Committee planned, coordinated, and carried out in 1996 and 1997, select businesses, institutions, and individuals were recognized for their efforts in promoting seismic safety in Utah.

At the 1996 conference, Lt. Gov. Olene Walker presented the first USSC Earthquake Safety in Utah Award to the *Salt Lake Tribune* and its Science Writer, Lee Siegel. The citation noted that the morning daily reported on earthquake-related activities in Utah and made an important contribution to increasing awareness and promoting earthquake safety among Utah's citizens, businesses, and decision-makers. Siegel spearheaded the reporting of earthquake issues, and his editors featured those reports and other earthquake-related articles prominently and supported earthquake safety.

The first Certificate of Excellence was awarded to Brigham Young University for its comprehensive campus-wide and community-wide earthquake safety efforts, including (1) providing earthquake awareness and preparedness information to all students and staff, (2) providing Community Emergency Response Teams (CERT) training for 118 employees, (3) developing an emergency communications system and comprehensive disaster-response plan, (4) maintaining 72-hour food and water supplies for all students, and (5) creating an on-going seismic upgrade plan for existing facilities.

The second Certificate went to the Salt Lake City School District for its pioneering efforts and initiative in upgrading older schools and improving earthquake safety. The district was the first in Utah to commission a district-wide evaluation of its buildings. Based on those findings, the district implemented a plan to retrofit and replace the schools that need upgrading.

The third Certificate went to Hyde Park City for involving its community in disaster planning, providing CERT instruction, holding mock disaster exercises, replacing or relocating city offices and water-system components to safer structures and locations, and including seismic hazards in its master plan and zoning ordinances.

At the 1997 conference, two organizations were recognized for their mitigation efforts. The USSC gave its Award for Outstanding Contributions to Earthquake Safety in Utah to Mountain Fuel Supply Company for its efforts to provide awareness and safety information to all its employees and customers. Mountain Fuel conducted company-wide earthquake response exercises, was involved in a long-term program to upgrade its distribution lines and facilities to improve earthquake resistance, and exceeded building code requirements in its new facilities.

The Utah Department of Transportation received the Certificate of Excellence for implementing a state-of-the-art seismic design of the Interstate 15 reconstruction project. The criteria exceeded code requirements and were designed to help ensure the survival of this critical roadway even in the event of the strongest ground shaking expected.

Outcome

The Commission, together with its goals and objectives, was featured prominently in the two major daily newspapers in Salt Lake City and on the local television news channels, thus raising the awareness of state and regional residents to the issue of seismic safety.

RECOGNITION OF EFFORTS BY COMMISSION STAFF TO ADVANCE EARTHQUAKE EDUCATION AND AWARENESS

<u>*STRATEGIES ADDRESSED*</u>

1.1 — Inform citizens about earthquake hazards and risks.
1.2 — Incorporate earthquake education in school curricula.

<u>*ACTION*</u>

The three organizations that are the foundation of the earthquake program in the state have received regional and national recognition of their programs in education and awareness.

The University of Utah Seismograph Stations' Earthquake Education Services (EES) outreach effort encouraged earthquake science and safety instruction in Utah schools by meeting teachers' needs for activities, materials and workshops. Its "Earthquakes in the Utah Core Curriculum" project received funding from FEMA. The project brought teachers and geologists together to develop grade-level-appropriate lessons and hands-on activities in grades 3, 5 and 9. The teacher/geologist teams traveled to individual school districts to instruct teachers and distribute activity packets and teaching materials. As the result of popularity of this program, CEM's Earthquake Preparedness Information Center (EPICenter) has provided three additional years of funding to continue the teacher workshops.

EES also compiled information on 48 damaging earthquakes that have occurred in the Intermountain West in the past 70 years, using that information to produce "Earthquakes in the Intermountain West," a traveling exhibit of photographs, text, and graphics. The exhibit was developed with funding from the National Earthquake Hazards Reduction Program (NEHRP) through the U.S. Geological Survey (USGS). The target audience is the general public and school communities. The 8-foot by 19-foot free-standing display has been placed in libraries, government buildings, small museums, and earth-sciences conventions.

The demand for the display was so great that a second one was purchased by the EPICenter. The Utah State PTA and the EPICenter have provided funding for travel and shipping costs for the displays which have traveled not only throughout Utah, but have been sent to Idaho, Montana and Wyoming. EPICenter also provides maintenance funding for the displays.

CEM's Earthquake Preparedness Information Center (EPICenter) published "The Utah Guide for the Seismic Improvement of Unreinforced Masonry Dwellings." The publication fills a need for information dealing with unreinforced masonry homes and the means by which to seismically retrofit them. It also provides homeowners, engineers, and general contractors with guidelines to assist in seismic retrofitting activities.

The UGS's Geologic Extension Service produced a series of maps and brochures that detail the earthquake hazards and risks in Utah. The series was written for the general public, real estate agents, and public officials and was distributed at scientific conferences, teachers' workshops, and state and county fairs.

As mentioned previously in the Prepared Schools portion of this report, the USSC's School Subcommittee developed a certificate for "Effective Drills and Safe Surroundings" for schools. This program received national recognition recently at FEMA-sponsored conference in Seattle.

<u>OUTCOME</u>

The EES, EPICenter, and UGS were recognized by the Western States Seismic Policy Council (WSSPC) at their 1997 Annual Conference in Victoria, B.C. The EES effort was a co-winner with the California Seismic Safety Commission's Seismic Retrofit Practices Education Program, of the Award for Overall Excellence and won the Award of Excellence in Outreach to Schools. The CEM brochure won the Award for Excellence in Mitigation Efforts, and the UGS initiative won the Award for Excellence in Outreach to the General Public.

The USSC's School Subcommittee was a co-winner with the Washington Division of Emergency Management and the Nevada Seismological Laboratory for WSSPC's National Awards in Excellence 2000 for Educational Outreach to Schools.

BUILDING-CODE ENFORCEMENT AND PLAN REVIEW

STRATEGIES ADDRESSED

3.1 — Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.
4.4 — Ensure design professionals and building officials are kept current on relevant geoscience information.

ACTION

In July 1996, the Engineering and Architecture Standing Committee (EASC) prepared a White Paper on building-code enforcement and plan review and presented it to the Utah Advisory Council on Intergovernmental Relations (UACIR). The proposal included suggested amendments to state law regulating the qualifications of building officials and plans examiners. The proposed changes also required all funds collected as a surcharge on building permits to be used solely for the purpose of code education and training.

The Commission noted in its White Paper that, although building code enforcement has improved in Utah over the past decade, serious deficiencies still exist. As a result, there are inequities for owners, builders, and citizens in general—including varying costs of construction from one jurisdiction to another, varying insurance rates from one city or county to another, under-regulation, and over-regulation. The solutions proposed by the Commission would include:

- Depositing all building permit revenues in a dedicated, non-lapsing fund.
- Establishing a regional or statewide agency that would provide assistance to local jurisdictions in meeting the objective of providing a full-service inspection program, to include quality control audits, special inspection coordination, code development, approved fabricator programs, support for absenteeism/overload circumstances, plan review for complex structures, engineering review, training, and maintenance of a technical library. The agency would be funded from the revenues derived from building permits.
- Appointing a state building codes administrator or building official to serve as technical support to the Uniform Building Code Commission (UBC) and to coordinate training needs.
- Creating minimum standards of competence for building officials and plans examiners.
- Ensuring that all state and school buildings would be accorded the same high level of examination and inspection as any other construction project, as provided for by the proposed legislation.

State Senator Craig Peterson, who represented the Senate on the Commission, sponsored the legislation as Senate Bill 135 in the 1997 General Session of the State Legislature. The measure received the support of the UACIR and the Inspector Licensing Board of the UBC Commission, but was opposed by the Utah League of Cities and Towns because of the funding issue.

Outcome

Senate Bill 135 passed the Senate by a comfortable margin but was narrowly defeated in the House during the 1997 General Session of the State Legislature. The EASC, with the support of the UBCC, then carried the issue to the Division of Professional Licensing (DOPL) in an attempt to get the rules changes incorporated into the State Inspector Licensing Law. That effort is ongoing.

SEISMIC STRENGTHENING OF EXISTING BUILDINGS

STRATEGIES ADDRESSED

3.1 — Enforce the state amendment to the Uniform Building Code which requires building building owners to install roof anchors and parapet bracing when reroofing their buildings.
3.8 — Improve the safety of older high-occupancy buildings (250 persons or more) to be structurally competent enough to withstand moderate to large earthquakes

ACTION

A fundamentally important way to promote earthquake safety in Utah is to reduce the number of seismically dangerous buildings within the state. It has long been recognized that unreinforced masonry buildings, referred to as URMs, are a major life-safety hazard in an earthquake, and this type of construction was common in Utah until about 1970.

At the Commission's April 1999 meeting, Commissioner James Bailey, a structural engineer, proposed that the Commission advocate a statewide ordinance, similar to ones successfully enacted in Seattle, Portland, and numerous jurisdictions in California, that would mandate when and how much retrofit was needed when an existing, non-residential URM building was remodeled. An ongoing process ensued informally termed the "existing building initiative."

In May 1999, the Commission asked the Structural Engineers Association of Utah (SEAU) for guidance as to the need for a statewide "existing building ordinance." Should regulation be advocated for the seismic retrofitting of certain classes of existing buildings in Utah—given the accelerating growth and development in seismically dangerous parts of the state? In response, the Seismic Committee of SEAU formulated a White Paper entitled, "Seismic Strengthening of Existing Buildings," dated July 8, 1999.

At a meeting of the Commission on July 9, 1999, Ken Willmore, chair of SEAU's Seismic Committee, presented the recommendations of his organization. A draft resolution approved by the SEAU board supported the need for regulations regarding the seismic retrofitting of existing buildings. The resolution suggested which actions should trigger the seismic upgrade of certain buildings, suggested existing documents to be used as guidelines for establishing a statewide code, recommended minimum seismic forces to be addressed by the code, and recommended the use of tax breaks and reduced insurance rates as incentives to make seismic upgrading attractive to building owners.

On July 14, 1999, the Commission wrote to the Uniform Building Code (UBC) Commission urging the adoption of the Uniform Code for Building Conservation (UCBC 2000) for the state of Utah and recommending that the UBC Commission take steps to ensure the enforcement of an existing statewide amendment to the Uniform Building Code which requires building owners to install roof anchors and parapet bracing when reroofing their buildings. Adoption of the UCBC

2000 code would require and enforce at least a partial seismic upgrade when URM buildings in Seismic Zone 3 have their lives extended through major remodeling.

Representatives of the Commission appeared before the UBC Commission on August 20, 1999, and again on March 17, 2000, to advocate the requests described above. At the August 1999 meeting, the UBC Commission declined to take immediate action, citing potential costs and the need to build widespread political support. Instead, the UBC Commission members unanimously voted to announce their intent to consider adoption of the code and encouraged stakeholders to speak out on the issue. At the March 2000 meeting, faced with legal and other complications that confounded simple adoption of the UCBC Code, the UBC Commission referred the matter to its Structural Advisory Committee—encouraging a continuing partnership with USSC and SEAU in order to prepare further recommendations and to pursue educational outreach for promoting awareness of the existing "parapet" ordinance.

OUTCOME

In September 2000 the Uniform Building Code Commission passed a resolution recommending "that local jurisdictions within the State of Utah consider adoption of 'The Uniform Code for Abatement of Dangerous Buildings—1997,' 'The Uniform Code for Building Conservation—1997,' and 'The Guidelines for Seismic Retrofit of Existing Buildings—2000'." The process continues of attempting to enact formal statewide adoption of such codes—beyond simply recommending their local adoption.

Also in September 2000, a committee consisting of representatives from the Structural Advsisory Committee of the UBC Commission, SEAU, and USSC published a brochure, "Earthquakes and Roofing—What You Need to Know About Seismic Bracing When Reroofing an Existing Building." The brochure describes the "Utah Parapet Ordinance" and its implications and is being actively used in a statewide educational campaign.

SEISMIC VULNERABILITY OF STATE BUILDINGS

STRATEGIES ADDRESSED

3.3 — Improve the post-earthquake operational status of essential service buildings.
3.4 — Reduce structural hazards of government-owned buildings.

ACTION

In September 1996, the Commission presented a request to the Utah State Building Board (USSB)—similar to a high-priority request made by the Commission one year earlier to the Governor—that $10.5 million be added to the annual budget of the Division of Facilities Construction and Management (DFCM) in order to assess the seismic vulnerability of state buildings and to begin to retrofit those in most critical need.

The USSB subsequently gave the request a high priority and forwarded it to the Governor's office for inclusion in the fiscal year 1997-1998 budget. However, the requested funds were not included in the Governor's final budget recommendation for that year.

At the Commission's quarterly meeting in October 1999, Commissioner Matthias Mueller of DFCM summarized DFCM responsibilities for enforcing construction standards, including those for seismic safety, in state buildings. Code requirements, supplemented by DFCM design criteria, are implemented in the design of every new state facility, and a team of licensed inspectors from DFCM inspects state construction projects to ensure code compliance.

Mueller outlined results of a survey of 193 older state buildings indicating that 111 of the 193 buildings surveyed by that date needed structural upgrading. Buildings which had already undergone seismic and other upgrades included the Utah Industries for the Blind, Utah State University's Old Main building, Weber State University's Browning Performing Arts Center, the Governor's Mansion, the University of Utah's Kingsbury Hall, Snow College's Noyes Building, and Salt Lake Community College's Grand Theater.

According to Mueller, DFCM assumes that approximately 51 percent of state-owned buildings comply with the Uniform Building Code because they were constructed after the code was first implemented in 1974. Commissioner James Bailey noted that buildings constructed between 1974 and 1985 should not be presumed to comply with the code because quality control then was not as stringent as current practice.

OUTCOME

Despite the Commission's unsuccessful attempt in 1996 (and earlier in 1995) in advocating dedicated state funding for progressively remediating the seismic vulnerability of older state-owned buildings, progress is being incrementally made in seismically strengthening selected

buildings as part of major remodeling projects. Standards for seismic safety of new state facilities are routinely enforced by DFCM.

During the fiscal year 2000-2001, an amount of $36.7 million was appropriated to DFCM for improvement projects—separate from capital development projects—which will enable some seismic upgrades (e.g., seismic bracing when reroofing). Some of the capital development projects also include seismic upgrades.

THE SAFETY OF CONSTRUCTION IN DOWNTOWN SALT LAKE CITY

STRATEGIES ADDRESSED

1.1 — Inform citizens about earthquake hazards and risks.
4.1 — Reduce earthquake losses by mapping and identifying geologic hazards.
4.3 — Make land use compatible, through local government ordinances, with known hazards.
4.4 — Ensure design professionals and building officials are kept current on relevant geoscience information.

ACTION

In 1998 and 1999 the Commission served as a sounding board and forum for concerns about fault-displacement hazards associated with active faults in the Salt Lake City metropolitan area. In 1997 Salt Lake County published a new version of its geologic hazards map, basing the depiction of active faults on a 1992 map produced by the U.S. Geological Survey. Unfortunately, Salt Lake County's 1997 map differed significantly from its earlier 1989 geologic hazards map, which showed that a branch of the Wasatch fault, known as the Warm Springs fault, may trend through downtown Salt Lake City approximately along West Temple.

As a consequence, several downtown projects were approved by Salt Lake City without the requirement to perform special studies for surface fault-rupture hazard.

Craig Nelson, Salt Lake County geologist at the time, brought the matter before the Commission in January 1998 after an investigative piece in a local newspaper revealed the discrepancy. He described efforts he had begun that would develop consistent standards for the County to follow in order to ensure a minimum acceptable scope-of-work and independent review of any geotechnical report prepared for developers. His plan would require all consultants to use the same map—the 1989 one—until a newer one could be prepared that showed the existence of the Warm Springs fault trend.

He also proposed to create a geologic review board to consider and approve all changes to the 1989 map and to hear any appeals of the county geologist's recommendations. The 1989 map would be made available through the Internet to improve the quality of information used for development and ensure a consistent set of standards with respect to seismic safety issues.

In early 1999 the issue of whether there was an active fault beneath the downtown area was raised again when contractors working on the Salt Palace Addition outlined for the Commission, at its January quarterly meeting, some evidence suggesting that a fault may indeed run directly through the site in a north-to-south trend consistent with the 1989 map projection.

Kenneth Ament, president of the construction company working on the addition, said his company addressed the potential for a fault on the site before beginning construction by drilling

12 boreholes into Lake Bonneville sediment, about 60 feet below the grade of 2nd South. The addition was designed to include an underground parking structure and an exhibit hall above.

The drilling revealed no evidence of a fault, but because of the difficulty in trenching posed by existing structures, the geotechnical report on the site recommended instead the inspection of cuts as excavation progressed. At 23 feet below the grade of 2nd South, the contractors uncovered geologic features that showed tectonic characteristics. They dug three trenches to provide a clearer view of the features and notified the state and county.

Initial indications were that the features were caused either by tectonic faulting or by liquefaction, which is not tectonic in nature. Work was suspended for 30 days to do more trenching closer to the existing Salt Palace structure to study the evidence more closely and to perform carbon dating on the deposits.

One consultant's conclusion was that the features uncovered were evidence of an extension of the Warm Springs fault, which manifests as a 30-foot downdrop just one mile north of the Salt Palace. Geologists have speculated that the Warm Springs fault could run as far as 4th South along the same line. Another consultant's conclusion was that the features resulted from liquefaction-induced lateral spreading.

Geologists examining the trenches said they showed sand dikes characteristic of liquefaction and displacement vertically, producing a graben—which represents pulling apart.

OUTCOME

Nelson resigned as Salt Lake County Geologist soon after his presentation to the Commission, and Darlene Batatian, the new Salt Lake County Geologist, continues to further his initiative. Salt Lake County submitted its contradictory consultants' reports on the Salt Palace to Salt Lake City. After obtaining a third-party review of the reports, Salt Lake City accepted the finding that the features were liquefaction-induced and permitted the project to continue. The contractor redesigned the foundation footings to accommodate the possibility of minor movement and resumed work on the structure, which is expected to be completed by the summer of 2001 in time for a major trade show. The facility will also serve as the main media center for the 2002 Winter Olympic Games. Factions within state and local government politicized the debate about whether the features represented an active fault or merely liquefaction. Consultants made equally compelling, but contradictory scientific presentations at the Association of Engineering Geologists annual meeting in Salt Lake City in October 1999.

VULNERABILITY OF THE STATE'S LIFELINES, INFRASTRUCTURE, AND WATER AND WASTEWATER SYSTEMS

STRATEGIES ADDRESSED

3.12 — Improve lifeline survivability in the event of an earthquake.
3.13 — Improve earthquake performance of water and waste-water systems.
4.6 — Reduce earthquake-induced liquefaction risk to highway structures.
4.7 — Determine appropriate seismic design coefficients for highway bridges.
5.3 — Conduct lifeline collocation vulnerability studies.

ACTION

The Lifelines and Infrastructure Standing Committee (LISC) began creating in 1998 a GIS-based inventory of all the important lifelines in Utah, including transportation routes and utility corridors, with a primary focus on the Wasatch Front area. The committee is also studying the issue of collocation of utilities, a situation that tends to magnify damage to lifelines during earthquakes.

The Lifelines Committee of the American Society of Civil Engineers (ASCE) conducted a survey in 1995 of Utah's approximately 300 water-system groups and 150 sewer-system groups regarding their knowledge of earthquake vulnerability. From that information, Mr. Carl Carpenter, a former member of ASCE's Water and Sewer Technical Committee, identified the need for basic education and developed a presentation to show those groups how to evaluate their own systems. In March 1998, Mr. Carpenter volunteered to make this presentation, under the auspices of the Commission, to operators of water and wastewater systems throughout Utah.

OUTCOME

The Commission agreed to fund further presentations by Mr. Carpenter and to help update the information with the latest data on water and wastewater systems in Utah.

The compilation of a GIS-based inventory of critical lifelines in Utah is continuing—in part, under combined efforts with the Utah Division of Comprehensive Emergency Management through the implementation of Hazards United States (HAZUS), a GIS-based software program for assessing vulnerabilities of the built environment to earthquakes and other hazards.

Members of the Commission are also actively involved on the Infrastructure Protection Subcommittee of the Utah Olympic Public Safety Command, whose efforts are aimed at making Utah's critical infrastructure disaster-resistant before, during, and after the 2002 Winter Olympics.

INTERSTATES 15 AND 80 BRIDGE RECONSTRUCTION

STRATEGIES ADDRESSED

3.12 — Improve lifeline survivability in the event of an earthquake.
4.6 — Reduce earthquake-induced liquefaction risk to highway structures.
4.7 — Determine appropriate seismic design coefficients for highway bridges.

ACTION

Attention to improved seismic safety for Utah's highway bridges and structures was a key part of the Commission's 1995 strategic plan, and individual members of the Geosciences Standing Committee (GSC) have been actively involved in advancing that safety. Prior to the $1.59 billion I-15 reconstruction project, the Utah Department of Transformation (UDOT) estimated that half of the Salt Lake Valley's deteriorating freeway bridges would collapse if a major earthquake hit the area.

In 1996, four members of the GSC served on an I-15 Corridor Seismic Advisory Committee to assist UDOT in establishing seismic design criteria and in reviewing and advising on the acceptability of earthquake-related studies and design recommendations made by I-15 consultants. The committee was instrumental in persuading UDOT to use design standards for the project that were higher than those it conventionally uses, so that freeway bridges would not collapse, but at most sustain repairable damage during a large earthquake on the Wasatch fault.

Following its attention to the seismic design of I-15 highway bridges and structures, UDOT co-sponsored a technical conference in January 1999 to address the problem of seismic retrofit of its highway bridges elsewhere in the state. Attention notably turned to aging highway bridges on I-80 between State Street and Parley's Canyon that posed potential losses of $170 million—and acute disruption of transportation—if hit by a magnitude 7 earthquake. Partial reinforcement of the 25 freeway bridges on that stretch of I-80 was scheduled to begin in the summer of 1999 to help keep those bridges operational for 15 years until they could be rebuilt completely.

Researchers at Utah State University and the University of Utah are conducting studies on old highway structures that were torn down during the I-15 reconstruction process. These old bridges and overpasses have become experimental devices that structural engineers use to determine if various shaking techniques can reveal structural damage in a bridge. The ability to use the condemned bridges gives the researchers information they can compare to results from national laboratories on the behavior of steel girders—information that cannot adequately be acquired in any other testing environment.

A research team from Brigham Young University is investigating the earthquake resistance of steel pilings used on the I-15 project, using a form of seismic testing known as static and statnamic loading, to study how the pilings will hold up under the estimated stresses of an earthquake.

OUTCOME

Seismic design standards were used in the I-15 reconstruction project that significantly exceed minimum national highway standards, ensuring that the I-15 bridges will withstand the strongest earthquake shaking expectable without collapse. Damage that may be sustained will be repairable so that the bridges can be returned to service relatively quickly. In the case of reinforcing aging highway bridges on I-80 between State Street and Parley's Canyon, potential losses of as much as $170 million due to a magnitude 7 earthquake will be reduced to about $17 million, thanks to selective seismic retrofitting. Ongoing research by university scientists and engineers will allow engineers to ensure the earthquake safety of highway bridges in Utah in a cost effective way without over-building structures.

FUTURE NEED—AN EVALUATION OF UTAH'S TRANSPORTATION LIFELINES

While new facilities are designed and constructed to a higher level of seismic resistivity than in the past, much of Utah's transportation system was constructed prior to the development of modern seismic codes and engineering practices. It is important to identify the seismic vulnerability of the state's transportation lifelines. While the emphasis will be on State owned facilities, this exercise should also include city and county facilities as well.

The first step should be to determine the transportation lifelines that will become critical after a major seismic event. The effort should focus on routes adjacent to hospitals, fire stations, schools, the airport, etc., and requires local and regional planning input. Next, an evaluation of the bridges along the critical lifelines will need to be evaluated for seismic vulnerability. Bridges determined to be seismically vulnerable should be identified and prioritized. At a minimum, this information can be used by bridge owners when performing rehabilitation work on critical lifeline bridges. At a maximum, the information can be used to develop long range seismic retrofit strategies for Utah's bridges. UDOT has planned a research project to perform all or part of this evaluation including prioritizing, but as of now it is unfunded. The USSC will provide information regarding the limited work that has been accomplished in this endeavor, so the UDOT research effort can build on what has been accomplished to date. The USSC will also provide oversight and support as requested by UDOT.

LOCAL GOVERNMENT NEEDS FOR GEOSCIENCE INFORMATION AND TRAINING TO REDUCE RISKS FROM EARTHQUAKES AND OTHER GEOLOGIC HAZARDS

STRATEGIES ADDRESSED

4.1 — Reduce earthquake losses by mapping and identifying geologic hazards.
4.2 — Perform geologic hazards investigations for critical public facilities.
4.3 — Make land use compatible, through local government ordinances, with known hazards.
4.4 — Ensure design professionals and building officials are kept current on relevant geoscience information.

ACTION

In 1999, the Geoscience Standing Committee (GSC) and the Utah Geological Survey (UGS) established the Guidelines Advisory Committee (GAC) to determine what products and services would be needed, who should provide them, and what resources might be required by local governments. The GAC also addressed possible roles of local government insurers — Utah Risk Management Mutual Agency (URMMA) and Utah Local Governments Trust (ULGT) — in encouraging risk reduction.

The Commission relied on some investigational and educational priorities of the University of Utah Seismograph Stations (UUSS), the Division of Comprehensive Emergency Management (CEM), and the Applied Geology Section and Geologic Extension Service of the UGS in dealing with this issue. Other organizations involved in furthering the initiatives of the Commission include the Utah Department of Transportation (UDOT), Utah State University (USU), and Brigham Young University (BYU).

The GAC identified the following local government groups as having specific needs for geoscience information:

- planners, who work directly with developers, landowners, and geotechnical consultants in regulating land use;
- building officials, who perform field inspections of sites, and in some rural jurisdictions, perform all of the duties of city/county engineers and planners; and
- elected officials and administrators, who must be informed of the dangers to citizens in their jurisdictions posed by geologic hazards to help them implement appropriate risk-reduction measures.

The GAC identified the products and services needed by each of those groups, the likely preparers of the information, possible sources of funding, and steps needed for implementation.

Planners use geoscience information to prepare, adopt, and enforce ordinances and prepare master plans that reduce losses from geologic hazards. Planners should understand hazards and be able to inform developers and landowners of studies required prior to approval of subdivisions or other land uses. The earth-science information products most valuable to planners, listed in order of priority, are:

- Special-study-area maps showing where geologic hazards may exist. These maps are chiefly for use in ordinances to indicate where special studies are required and possibly for disclosure in real-estate transactions. They would be prepared by the UGS, county geologists, or private consulting geologists. The UGS and local governments would share funding while consultants would be eligible for direct funding. In order to provide this product, the preparers would complete new maps and update existing maps, and conduct workshops in the use of geologic-hazards maps in ordinances and for disclosure.
- Non-technical brochure(s) explaining hazards and risk-reduction measures that planners can hand out to developers and homeowners; training for planners to better understand geologic hazards and risk reduction; compilations of individual packets of information specific to a city or county. The preparers would be the UGS, county geologists, and UUSS’s Earthquake Education Services. No outside funding has been identified; possible contributions could come from cities and counties for specific information packets. The new brochures would cover all geologic hazards, and the preparers would more widely distribute those already available and provide workshops and training for planners to increase understanding of geologic hazards and risk-reduction measures.
- A brochure explaining the process of using geologic-hazards information and maps, ordinances, and disclosure to reduce risks and losses. Preparers would be the UGS and county geologists. There has been no outside funding identified. Preparers would produce the brochure and distribute and train users, perhaps through the American Planning Association (APA), Utah League of Cities and Towns (ULCT), Utah Association of Counties (UAC), and URMMA.

Building officials must be able to recognize evidence for hazards in the landscape and in excavations. They must be familiar with seismic and grading requirements in the UBC. The Utah Chapter of the International Conference of Building Officials (ICBO) could present workshops and field training at its annual meetings, and the URMMA could host workshops and hold field trips for building officials in UBC requirements and field hazard recognition with help from the UGS and county geologists. Funding could come from the UBC Commission (Division of Occupational and Professional Licensing) education fund.

Elected officials and administrators need succinct, straightforward information on geologic hazards and the role that local government can play in reducing risk and liability. Workshops are impractical because elected officials often change every two years; information products most valuable to this group, listed in order of priority, are:

- A brochure discussing geologic-hazards liabilities and Utah case law affecting cities and counties, and ways to promote safety and reduce liability. The preparers would be city/county attorneys, other legal council, or law-school students/faculty. Funding sources have not been identified, but the need could be met by encouraging and facilitating research by City/County attorneys or as a research project for law-school students/faculty.

- Analysis of costs and benefits of geologic-hazards risk reduction. The preparers would be the UGS, CEM, or the HAZUS Data Users Group. Funding sources have not been identified. HAZUS (see p.33) can produce loss estimates for earthquakes and other hazards. For all hazards, the need exists to compile historical losses, estimate costs of risk reduction, and compare actual and projected losses to risk-reduction costs to determine benefits.

URMMA and ULGT provide insurance coverage to their local government members. URMMA, in particular, promotes risk reduction by providing training and assigning ratings to local government members based on their risk-reduction efforts. URMMA could further help local governments manage risks from geologic hazards by including geologic hazards in their training workshops and risk ratings. The URMMA Executive Committee oversees risk ratings and would need to approve any proposed changes or additions to the rating system to include geologic hazards. Other groups highlighted by URMMA that need geoscience information to help encourage risk reduction include the ULCT, UAC, local Councils of Governments (county commissions and mayors in each county), URMMA itself, and ULGT. This information should include examples of risks taken and losses incurred by local governments from geologic hazards.

A need exists for geoscience information in a form designed for local government officials to use in promoting risk-reduction measures. Planners need maps depicting geologic-hazard special-study areas and information explaining hazards and the risk-reduction process. Building officials need training in UBC requirements and field hazard identification. Elected officials and administrators need information on local government liability and responsibility to protect public safety with respect to geologic hazards and the costs and benefits of risk reduction. Partnerships with various professional (APA, ICBO) and local government (ULCT, UAC, URMMA, ULGT) groups can greatly facilitate risk reduction.

Completion of these geoscience-information products and services becomes the responsibility of the designated preparers, as facilitated by the GSC and UGS. Because completion depends on factors outside the GAC's control, no time tables or schedules can be set for completing products or performing services.

In light of those needs, there have been several publications and technical studies produced by the UGS and others since July 1996, as well as new scientific and technical investigations involving the Applied Geology Section of the UGS and funded at least in part by the National Earthquake Hazards Reduction Program:

Non-Technical Publications

- *The Wasatch Fault* (PI-40), a brochure that explains the hazard the fault poses and gives examples of good and bad land uses in the fault zone, summarizes how often earthquakes occur on the fault, and discusses the potential for future activity. Several full-color photographs show what the fault is, where it is located, and how to recognize it.

- Earthquake hazard maps compiled by CEM of eastern Box Elder, Weber, Salt Lake, Davis, and Utah counties, showing critical facilities such as schools, hospitals, and dams, and locating liquefaction and surface-rupture hazards and landslides.
- *The Homebuyers Guide to Earthquake Hazards in Utah* (PI-38), a general-information pamphlet that discusses real estate concerns.
- *Earthquakes & Utah* (PI-48), a brief summary of seismic events that have affected Utah from Brigham City to St. George.

Technical Studies

- Surficial geologic map of the Nephi segment of the Wasatch Fault zone, eastern Juab County.
- Surficial geologic map of the West Cache fault zone and nearby faults, Box Elder and Cache counties.
- *Paleoseismology of Utah, Volume 6:* The Oquirrh fault zone, Tooele County, Utah: surficial geology and paleoseismicity.
- *Paleoseismology of Utah, Volume 7:* Paleoseismic investigation on the Salt Lake City segment of the Wasatch fault zone at the South Fork Dry Creek and Dry Gulch sites, Salt Lake County, Utah.
- *Paleoseismology of Utah, Volume 8:* Paleoseismic investigation at Rock Canyon, Provo segment, Wasatch fault zone, Utah County, Utah.
- *Proceedings Volume,* Basin and Range Province Seismic-Hazards Summit.

Scientific and Technical Activities

- A paleoseismic study of the West Cache fault zone (WCFZ), Cache Valley, Utah, which is between Logan and Brigham City, Utah's tenth and 16th largest cities, respectively. The UGS has excavated and logged four trenches to evaluate earthquake potential of the WCFZ and associated faults. The results provide a complete chronology of surface-rupturing earthquakes for western Cache Valley and the northern part of the populous Wasatch Front, and that information will permit accurate estimates of seismic hazard and risk.
- Seismic hazard mapping of Cache Valley using geographic information system (GIS) technology. The results help establish a customized protocol for mapping seismic hazards in the unique geologic environments of north-central Utah and provide seismic-hazard maps in a rapidly developing area near the northern Wasatch Front.
- A seismic hazard study of the Hurricane fault in southwestern Utah, which extends 250 kilometers from Cedar City, Utah, to Peach Springs, Arizona. The results of the investigation will be used to characterize the frequency of surface rupture and segmented behavior of the Hurricane fault, and will greatly improve understanding of seismic hazards in the region at a time when this information can be incorporated into design standards and building practices for on-going development.
- Development of a Quaternary fault database for Utah. Results of the study will provide a convenient reference for earthquake sources in Utah and add to the database for future National Seismic-Hazard Map updates.

- Geotechnical site-response mapping of the Salt Lake Valley, an area of high seismic risk characterized by deep, soft soils in the valley interior and shallow, stiff soils along the valley margins. This combination of geologic features tends to amplify earthquake ground motions relative to rock sites. The resulting maps produced by this effort are useful to earth-science consultants, geotechnical and structural engineers, local government officials, and researchers in the design of structures that do not require detailed site investigations, such as residential and small commercial and industrial buildings, where Uniform Building Code site coefficients are now commonly estimated or ignored. The maps are also being used to develop more accurate probabilistic ground-shaking estimates, regional ground-shaking models for loss-estimation studies, and earthquake scenarios for emergency response planning. The addition of this information to existing state GIS databases for fault zones and liquefaction-hazard zones will allow new data to be readily incorporated, and facilitate effective communication of earthquake hazards to Utah residents.
- A seismic hazard scenario for a magnitude 7 earthquake in Salt Lake City. An earthquake in Utah's metropolitan center would impact the lives of more than 1.3 million people, an area which includes all or part of eight Utah counties. Using ground-shaking maps of this area produced by an ongoing NEHRP-supported study by URS Corporation, UGS, UUSS, and Pacific Engineering & Analysis, the UGS will produce maps at a scale of 1:250,000 using GIS. The maps will be accessible to consulting engineers and geologists, planners, and state and local government agencies to ultimately serve as the scenario earthquake and be the focus for bringing together lifeline managers, engineers, contingency planners, and others to identify specific effects of the earthquake for emergency-response planning.
- Microzonation maps for earthquake ground shaking in the Salt Lake City metropolitan area. The UGS will publish a series of nine deterministic earthquake scenario and probabilistic ground shaking maps prepared by URS Corporation, UGS, UUSS, and Pacific Engineering and Analysis that ultimately will be used by the public, the engineering community, government agencies, and all interested parties involved in earthquake mitigation in Utah.
- Trenching efforts of the Wasatch fault zone. The UGS is assisting in a project to add detailed information of ancient earthquakes obtained by excavating large trenches on the Wasatch fault.
- Strong-motion recorders. Researchers from the USGS, UUSS, and UGS have installed and/or upgraded strong-motion accelerographs in the Salt Lake Valley that will record the next sizable earthquake in the valley. The goal of the study is to define how seismic shaking will affect the urban area during a major earthquake.

Outcome

The maps will add substantially to the information available to planners and public officials, who can use the maps to reduce the impact of seismic hazards on future development and manage post-earthquake response and recovery efforts. The trenching efforts will potentially aid scientists in earthquake forecasting worldwide and provide more accurate information on which to estimate damage in communities along the Wasatch Front. Data from the strong-motion sites will provide more statistically reliable data about the various soil types in the valley, and records from the array will be used by engineers and seismologists for investigations into structural responses, analyses of basin effects, ground-motion attenuation, and comparison of ground acceleration data with intensities.

RECOGNIZING EARTHQUAKE HAZARDS, ASSESSING RISKS FOR COMMUNITIES, AND PREPARING COMMUNITIES FOR EMERGENCY RESPONSE

STRATEGIES ADDRESSED

1.1 — Inform citizens about earthquake hazards and risks.
2.1 — Establish Community Emergency Response Teams (CERT) statewide.
2.4 — Enhance the integrated emergency management system statewide.
5.1 — Update estimates of direct losses to be expected from earthquakes.
5.2 — Evaluate the indirect losses associated with earthquakes.
5.4 — Conduct lifeline collocation vulnerability studies.

ACTION

The Utah Division of Comprehensive Emergency Management (CEM), with the active support of the Commission's Awareness and Education Standing Committee, (AESC), has been involved it two important activities: (1) implementing Hazards United States (HAZUS), a geographic information system-based software program that projects casualties, damage, and lifeline disruption, and (2) providing Community Emergency Response Team (CERT) training. Both initiatives are central to the concept of ensuring that all segments of the state's population will be able to face the emergencies inherent in the aftermath of an earthquake.

HAZUS is a software program that identifies a community's vulnerabilities; CERT training gives its initiates the experience and expertise necessary to respond to community needs.

In 1997, CEM began implementing HAZUS, a Geographic Information System (GIS) program that recognizes earthquake hazards and assesses risks for communities. With its roots in an Applied Technology Council (ATC) pilot project funded by the Federal Emergency Management Agency (FEMA), HAZUS uses a GIS-based software program to map and display demographic information about individual communities, given the size and location of a hypothetical earthquake. HAZUS can estimate the amount of ground shaking, the number of casualties and buildings damaged, the impact on transportation systems, the extent of disruption to utilities, the number of people displaced from their homes, and the estimated cost of repairing projected damage and other effects.

HAZUS projections can be used before an earthquake to:

- develop earthquake-hazards mitigation strategies as countermeasures to potential losses and disruption,
- develop preparedness or contingency plans, and
- anticipate the nature and scope of response and recovery efforts.

After an event, HAZUS information can be used to:

- project immediate economic impact for state and federal resource allocation and support,
- activate immediate emergency recovery efforts, and

- formulate long-term reconstruction plans.

CEM is now in the process of gathering more information about Utah, to include site-specific details about geology, building inventory, utilities, transportation systems, and engineering and geotechnical data. Such information will allow CEM to increase the accuracy of the HAZUS estimates and the ability to customize those estimates to the specific conditions of individual communities. To that end, CEM is working with the University of Utah Seismograph Stations (UUSS) and the Utah State Automated Geographic Reference Center (AGRC) to collect site-specific data. An oversight committee, consisting of representatives from AGRC, CEM, and UUSS will provide direction and coordination with all participating agencies. Funding for the effort will come from FEMA and the CEM Earthquake Program.

In addition, CEM staff in 1999 created a HAZUS Data Users Group (HDUG) to help build up and facilitate the use of the database. HDUG receives training in the use of HAZUS, develops a clearinghouse and associated security for the database, takes on the responsibility of updating information with the HAZUS model, and uses HAZUS analysis to encourage actions aimed at reducing future earthquake damage. At its first meeting, the HDUG saw a demonstration of HAZUS, learned where the databases are stored and how to contribute to them, and received encouragement to enlist support of other potential users and organizations. In the future, the HDUG plans to:

- provide basic and advanced HAZUS training;
- execute a Memorandum of Understanding with AGRC, which has agreed to act as the clearinghouse for the data, provide users with password access so they can contribute and retrieve information, and create a firewall to protect proprietary information;
- update default data, to include allocating funds for staffing and other expenses; and
- motivate agencies and organizations to reduce future earthquake damage.

Potential HAZUS users include representatives from:

- city and county agencies such as building inspectors, emergency management teams, planning offices, public works, utilities, and water and sewer districts;
- state agencies such as Public Safety, State Lands, UGS, Automated Geographic Reference Center, Transportation, and USSC;
- federal agencies such as the USGS, Army Corps of Engineers, and Bureau of Reclamation;
- local colleges and universities;
- the private sector such as utilities, cable television providers, oil and gas refineries and pipeline companies, and other large employers; and
- other organizations, both secular and religious.

CEM, in January 2000, conducted HAZUS training for 20 state and local government participants. The training was the first in the country on HAZUS 99, the latest version from FEMA. The training was conducted by Ken Taylor, Earthquake Program Manager from North Carolina.

HAZUS has the potential to raise awareness and serve as a catalyst for change. It can identify hazards and vulnerabilities so communities can focus on solutions. HAZUS helps organizations explore options to prepare for and reduce the effects of earthquakes, and it can be used to compare benefits to costs on projects to ensure that dollars are spent wisely. Eventually, HAZUS can add modules that can reflect other hazards, such as wind, flood, wildfire, and landslides.

The second of CEM's major initiatives has been CERT training, which is necessary to provide citizens with the basic skills to handle their own needs and to respond to the needs of their communities in the event of a disaster. CEM sponsors the program, trains the trainers, and encourages local jurisdictions and organizations to incorporate CERT training in their own disaster preparedness activities.

The course consists of 21 hours of training in:

- preparedness, to include introduction to disasters, impact of disasters on infrastructure, hazards posed by buildings and nonstructural items, and the role of CERTs in disaster response;
- fire suppression, to include identifying and reducing potential fire hazards, basic fire suppression strategies, firefighting resources, and firefighting techniques;
- medical training, to include treatment strategies for life-threatening conditions and principles of triage, head-to-toe assessments, treatment for head wounds, fractures, sprains, burns, and other injuries;
- light search-and-rescue, to include priorities and resources, techniques for assessment and searching, removing victims, and rescuer safety; and
- psychology and team organization, to include post-disaster emotional environments, the Incident Command System, CERT strategies, tactics, and documentation.

The class ends with a course review and a disaster simulation exercise. CEM oversees the program and ensures that the guidelines for instruction and training are followed.

OUTCOME

HAZUS has the potential of reducing Utah's vulnerabilities to natural hazards, while CERT training brings together private and public sector elements and ensures that they work together with city, county, and corporate emergency planners. CEM promotes effective communication among, and enhances the relationships of, emergency management systems statewide.

REAL-TIME EARTHQUAKE INFORMATION SYSTEM AND STRONG-MOTION RECORDING

STRATEGIES ADDRESSED

2.4 — Enhance the integrated emergency management system statewide.
3.12 — Improve lifeline survivability in the event of an earthquake.
4.8 — Develop incrementally a strong-motion program.
4.9 — Develop a statewide, real-time earthquake monitoring system.

ACTION

Initiatives aimed at strong-motion instrumentation and developing capabilities for real-time earthquake information have long involved scientists, engineers, and emergency managers from Utah's state earthquake program.

Important state needs in this regard were defined in 1989 when a legislative study of "Earthquake Instrumentation Needs of Utah" was assigned to the Legislature's Interim Appropriations Committee and the Office of the Legislative Fiscal Analyst—leading to the creation of a blue-ribbon panel co-chaired by then Senator Craig A. Peterson. Unfortunately, the recommendations of the panel went largely unheeded, save for some small one-time state funding to the Utah Geological Survey in 1992 that enabled seven strong-motion instruments to be installed at scattered sites along Utah's main earthquake belt.

The efforts of many—including advocacy by the Commission during 1998 and 1999—finally bore fruit in 1999 with the announcement that the University of Utah Seismograph Stations (UUSS) would receive federal funding during the federal fiscal year 2000, under a cooperative project with the U.S. Geological Survey, to begin building a real-time urban strong-motion network in the Ogden-Salt Lake City-Provo urban corridor. Thanks to this funding, the University of Utah's earthquake-recording network is being modernized into a multipurpose, real-time earthquake information system. The primary aim is to improve earthquake safety in Utah's dramatically growing Wasatch Front area by providing faster and better information—especially for emergency response and earthquake engineering. A secondary aim is to have basic real-time capabilities in place before the 2002 Winter Olympics.

With the funding from the U.S. Geological Survey, UUSS is installing new sensors, digital processors, computer networks, and communications for this modernized system, which by late 2001 will provide: (1) automated broadcasts of the location and size of a potentially disruptive earthquake, within a few minutes of its occurrence, and (2) automated computer maps (called ShakeMaps), available on the World Wide Web within several minutes of any significant earthquake, showing the geographic distribution and severity of ground shaking. (A ShakeMap is analogous to a Doppler-radar image, giving a useful overview of the location and severity of a potentially threatening disturbance.)

By September 2000, twenty modern digital strong-motion instruments were added to the UUSS seismic network in the Ogden-Salt Lake City-Provo urban corridor. Added funding is being provided in 2001 to expand this urban network to more than 40 stations, enlarging the geographic coverage. This new urban strong-motion network in Utah is being built with seed-funding for an Advanced National Seismic System (ANSS), a large-scale initiative now pending before Congress. If the ANSS receives full funding, Utah's urban network would eventually expand to about 500 stations along the Wasatch Front.

Unlike conventional sensors in the University of Utah's seismic network, strong-motion accelerometers capture high-quality recordings of ground shaking and are designed to stay on scale during moderate to large earthquakes of magnitude 5 or greater. Recordings of strong ground shaking in structures and on the ground near the source of moderate to large earthquakes are fundamentally important in earthquake engineering for setting guidelines in building codes and for safe, cost-effective design and construction practices.

Strong-motion monitoring is integral to a real-time earthquake information system, particularly for providing rapid information to crisis managers—such as public safety officials and operators of utilities, hospitals, dams, and other critical facilities and lifelines—who must make informed decisions for response and recovery when an earthquake happens. Rapid estimates of damage, losses, and impacts on population based on real-time ground-shaking information have become important in meeting requirements for a formal Presidential Declaration of disaster. The information also expedites federal recovery assistance to individuals and communities.

Key elements in successfully completing and sustaining a real-time earthquake information system in Utah will be: (1) capital funding for a major part of the system from federal sources; (2) state funding for a minor part (e.g., to extend coverage to seismically dangerous parts of Utah such as Cache Valley, Brigham City, Richfield, and the St. George-Cedar City area), together with a firm commitment to providing at least part of the system's long-term operational support; and (3) private-sector involvement, particularly in extending the geographic distribution of sensors and perhaps in sharing resources for digital communications.

OUTCOME

With federal funding through the U.S. Geological Survey, and as part of building an Advanced National Seismic System, the University of Utah's earthquake-recording network is being modernized into a multi-purpose, real-time earthquake information system—with special focus on Utah's dramatically growing Wasatch Front urban corridor. Benefits to Utah will include real-time information for emergency management, critical information for earthquake engineering and improved building codes, and new and valuable information for scientific understanding of earthquakes in Utah.

A basic real-time earthquake information system will be in place in the Wasatch Front area before the 2002 Winter Olympics, when international attention will demand rapid information, in the unforeseen event of any disruptive local earthquake activity.

A UNIFIED UTAH EARTHQUAKE MASTER MODEL

STRATEGY ADDRESSED

4.10 — Monitor faults using GPS measurements.

ACTION

At the October 10, 1997, quarterly meeting of the Commission, Robert D. Smith, Ph.D., Professor of Geophysics at the University of Utah, presented a proposal for a "Unified Utah Earthquake Master Model," intended to be a vehicle for integrating various types of earth-science information for earthquake research and practical applications. He described new measurements from Global Positioning System (GPS) monitoring which indicated higher-than-expected rates of extensional strain across an area encompassing the Wasatch fault. These results could be factored into, and would increase, probabilistic estimates of the ground shaking hazard in the Wasatch Front area.

The Commission referred his proposal to the Geoscience Standing Committee (GSC) to answer four questions: (1) Do the high GPS rates indicate that the earthquake hazard in the Wasatch Front region is higher than previously estimated? (2) Do the high GPS rates warrant immediate action by the Commission? (3) Is this unified master model proposal technically applicable in Utah? and (4) How should the Commission proceed?

At the January 9, 1998, quarterly meeting, the GSC reported to the Commission that the higher GPS rates do not necessarily indicate an increased earthquake hazard because of uncertainties in the measurements themselves as well as in the interpretation of the cause of the higher rates of movement. The GSC recommended that more continuous-monitoring GPS instruments be installed, that further scientific work be done on extensional strain measurement and interpretation, and that a scientific workshop be held under the auspices of the Commission to develop a strategic plan to consider the master model proposal and other geoscience initiatives.

Dr. Smith has continued his GPS research with funding from the U.S. Geological Survey (USGS), concentrating on three elements: (1) installation and maintenance of four continuous recording GPS sites on the Wasatch Front; (2) incorporation of data from six Harvard Smithsonian-Caltech Basin-and-Range continuous GPS stations in the eastern Basin and Range, for a total of 10 stations; and (3) research on understanding time-varying behavior of the Wasatch normal fault incorporating GPS-derived motions, the paleoseismic record, and fault stress interactions.

<u>Outcome</u>

Smith's efforts have resulted in the establishment of a 4-station continuous GPS network on the Wasatch Front. With the installation of six Harvard/Cal Tech stations in western and central Utah, at least ten continuous GPS stations transmit data on a daily basis. Furthering a master model approach to analyzing earthquake behavior in Utah awaits consensus-building among scientific researchers regarding the viability of such an approach.

NATIONAL SCIENCE FOUNDATION REQUEST FOR PROPOSALS TO FUND EARTHQUAKE-ENGINEERING RESEARCH CENTERS

OBJECTIVES ADDRESSED

3 — Improve the seismic safety of buildings and infrastructure
4 — Improve essential geoscience information

ACTION

In 1996 the National Science Foundation (NSF) issued a request for proposals to fund earthquake-engineering research centers. The Commission unanimously voted to support a proposal from a consortium including Brigham Young University (BYU), Utah State University, the University of Utah, Portland State University, the Oregon Department of Geology and Mineral Industries, and the Utah Geological Survey.

The principal author of the proposal, Matthew Mabey, Ph.D., of the Geology Department at BYU, said the proposed Utah center would have a geotechnical-engineering, rather than a structural-engineering, emphasis. The center would initially have two goals: (1) engage in research to develop and implement methods for supplying geotechnical-engineering design parameters for the cost-effective reduction of losses, and (2) advance the ability to quickly identify the most vulnerable structures, leading to more cost-effective expenditures to increase the benefit-to-cost ratio for mitigation. The completed proposal was submitted to the NSF in October 1996.

OUTCOME

In April 1997, the National Science Foundation announced it was re-evaluating the program and postponed funding decisions. Funding was ultimately awarded to three other proposed centers in California, New York, and Illinois.

THE RELEVANCE OF SEISMIC SAFETY COMMISSIONS

<u>*STRATEGIES ADDRESSED*</u>

1.1 — Inform citizens about earthquake hazards and risks.
3.1 — Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.
3.14 — Reduce structural hazards in older private buildings by retrofitting to current seismic building requirements.

<u>*ACTION*</u>

The Commission opened its 2nd Quarterly Meeting of 1999 to outside advice, inviting Ron Lynn, the chair of Nevada Earthquake Safety Council, to relate how the Nevada group maintains its relevance.

The Nevada Earthquake Safety Council is an independent organization that "hustles for its money," Lynn noted, adding that seismic safety issues have to be made "real."

"In Utah," he said, "you are trying to educate the public about a low-occurrence/high-impact event. You need to bring your message down to real issues: building and retrofitting to mitigate earthquake damage is smart and increases property values; educating school children about the potential for earthquakes and ways to survive them is good for the future; enforcing building codes that require setbacks from fault lines is good business. Trust your constituents, and remember: all building codes—in a very real sense—are written in blood."

Lynn, who is the Assistant Director of the Clark County, Nevada, Building Department, spoke during a luncheon forum to address building code issues. The hottest topic was the Gateway Project, which will involve extensive remodeling of older buildings on Salt Lake City's near-west side. Lynn's presentation, "A Rational Approach to Building Codes: Practical Issues and Local Challenges Relating to Seismic Codes, Retrofit, and Fault-Setback Ordinances," sparked lively discussions among the structural engineers and architects present. Lynn stressed that this kind of communication needs to continue until a consensus is reached, and that contractors and building officials must be involved.

<u>*OUTCOME*</u>

The Commission resolved (1) to go into the 2000 State Legislative Session with proposed changes to its charter that would include language allowing it to solicit funds rather than rely only on a small annual legislative appropriation, and (2) to actively persuade Utah's Uniform Building Code Commission to adopt updated seismic codes for new construction and remodeling projects.

DISASTER-RESISTANT COMMUNITIES

STRATEGIES ADDRESSED

1.1 — Inform citizens about earthquake hazards and risks.
1.3 — Disclose geologic hazards in real estate transactions.
3.3 — Improve the post-earthquake operational status of essential service buildings.
5.1 — Update estimates of direct losses to be expected from earthquakes [and mitigation strategies].
5.2 — Evaluate the indirect losses associated with earthquakes [and mitigation strategies].

ACTION

The challenge of improving earthquake safety in Utah inevitably faces changing circumstances and demands—which calls for versatility, both in focus and tactics. One prominent circumstance that has captured the Commission's attention is the growth dynamic in the greater Wasatch Front Area. Population in this area is well known to be growing dramatically from its 1995 base of 1.6 million and is projected to reach 2.7 million by 2020 and 5 million by 2050. This increases the urgency of taking actions that will make Utah's communities more disaster-resistant.

The Commission invited Natalie Gochnour, an economist in the Governor's Office of Planning and Budget, to its January 1998 meeting to present information gathered by the program *Envision Utah*, formerly known as the Utah Quality Growth Public/Private Partnership, sponsored by the Coalition for Utah's Future. Ms. Gochnour presented findings on population, transportation, air quality, water, and land use, all of which provided a useful perspective for the Commission in identifying future needs and priorities for earthquake-related mitigation actions. An inescapable fact is that Utah's future growth and development in the Wasatch Front area will take place right on top of the active Wasatch fault.

In terms of changing tactics, at the Commission's July 1999 quarterly meeting, the Awareness and Education Standing Committee (AESC) reported that they were working on two initiatives:

- making data on geologic hazards more accessible to policy- and decision-makers in Utah, and
- exploring ways to use lobbyists from private companies to advance the Commission's agenda in the State Legislature.

One of the premier issues identified by this committee was the creation of legislation that would mandate complete disclosure of geologic hazards to potential buyers of real estate. Utah does not now have such a requirement, and the committee will work with representatives and lobbyists from the real estate, construction, and insurance industries to make full disclosure a reality.

A tangible benefit of the close cooperation between federal, state, and local emergency managers in mitigating the effects of disaster was the awarding of FEMA funding to several Utah communities for *Project Impact: Building a Disaster-Resistant Community*. Communities awarded grants by FEMA include: Centerville, 1998; Salt Lake City, 1999; Logan and Moab, 2000; and Provo, 2001. The grants, ranging from $150,000 to 500,000 will be used to develop long-term cooperative initiatives by continuously engaging and leveraging the resources of the city with the resources of its private sector *Project Impact* partners.

Project Impact is a nationwide effort aimed at protecting families, businesses, and communities by reducing the effects of disasters. FEMA, in awarding the grants, recognizes the strong infrastructure of these communities and the willingness of representatives from the public and private sectors to work together to mitigate hazards, both natural and human-caused. *Project Impact* will be managed by communities' emergency management offices in cooperation with CEM and FEMA.

OUTCOME

The Commission is firmly committed to take actions that will help make Utah's communities more disaster resistant—particularly in view of the dramatic growth and development in the greater Wasatch Front Area. Funding from FEMA to selected communities in Utah under Project Impact will directly aid in creating disaster-resistant communities.

COMMISSION MEETINGS OUTSIDE THE SALT LAKE CITY AREA

STRATEGIES ADDRESSED

1.1 — Inform citizens about earthquake hazards and risks.
5.1 — Update estimates of direct losses to be expected from earthquakes.

ACTION

The Commission traveled to Brigham City for its second quarterly meeting of 1998 to meet with the public as well as local and state officials from Box Elder, Cache, and Weber counties. The Commission's second quarterly meeting of 2000 was held in Provo at Brigham Young University (BYU) with representative from the communities in Utah County. Meeting in public and away from Salt Lake City provides an excellent opportunity for the Commission to spread its message of taking responsible action to promote earthquake safety in communities along the Wasatch Front. The Commission's second meeting of 2001 will be held in Ogden.

After some standard introductory presentations by various commissioners, the Brigham City meeting became an open discussion between the Commission and local officials, who asked what defensive actions could be taken to advance earthquake safety in northern Utah and how the Commission could help them achieve results. There was additional discussion about the political and economic problems the region faced in implementing prudent, defensive actions and what was needed that the Commission might be able to provide or facilitate. Local officials emphasized the need for timely information and updated maps of earthquakes and associated hazards. The officials believed they were doing a good job of planning for emergency response, especially in the first hours and days after an event — but there was less satisfaction with the capability for reducing exposure in advance of the event. Citizen awareness of and support for seismic safety issues were coming from schools and Parent-Teacher Associations, while resistance was noted in public sectors having to do with land-use planning. There followed a discussion on problems associated with enforcement of restrictions on building in unsuitable areas and whether building codes were adequate. Local officials believed they were doing a good job of plan review checks and quality control on contractors.

At the meeting in Provo at BYU, several speakers—at the invitation of the Commission—presented their views on issues related to earthquake hazards, safety, and emergency response and preparedness. Kerry Baum, Emergency Preparedness Coordinator for BYU, described efforts by the university to implement earthquake-safety measures on campus. These efforts include extensive employee training, food stockpiling, purchase of water-purification equipment, and non-structural reinforcement to reduce hazards. Les Youd, Chairman of the Civil and Environmental Engineering Department at BYU, discussed earthquake hazards within Utah County and related engineering techniques. Tricia Porter, Emergency Management Coordinator for Provo City, reported on the Provo Emergency Operations Center and implementation of its functions during future earthquakes. Chuck Hugo, Chief Building Official for Provo City, spoke about construction techniques within the city and the relationship of infrastructure to earthquake hazards. Jerry Grover, Chair of the Utah County Commission, described county efforts to address earthquake hazards in comprehensive planning documents.

<u>Outcome</u>

Holding Commission quarterly meetings outside of the metropolitan area of Salt Lake County has become a valuable out-reach tactic. More meetings in other regions of the state are planned, and local officials and the general public welcome the visits and the open exchange of ideas and concerns.

PRIORITIES FOR THE FUTURE

The scope of what has to be done to improve earthquake safety in Utah demands simultaneous attention to the many facets of being prepared to (a) withstand, (b) respond to, and (c) recover from earthquakes. The diverse makeup of the Commission and its standing committees enables such attention. The Commission has identified nine important action items on which to focus next. All are relevant to three primary objectives in the Commission's 1995 strategic plan: (1) increase earthquake awareness and education; (2) improve the seismic safety of buildings and infrastructure; (3) improve—and effectively use—essential geoscience information.

In unranked order, the Commission's priorities for the immediate future are the following:

- Expand the Commission's "Prepared Schools" program to increase earthquake safety and disaster-preparedness in Utah's K-12 schools (see p. 3 and p. 5) and in institutions of higher learning.

- Advocate requirements for seismic improvements in older commercial and high-occupancy buildings during major remodeling or when certain other changes are made in order to increase life-safety during moderate to large earthquakes (see p. 17).

- Improve the survivability and post-earthquake usability of essential service buildings (see, for example, p. 19).

- Evaluate the seismic vulnerability of Utah's lifelines so that long-range seismic retrofit strategies can be developed (see p. 26 regarding transportation lifelines).

- Ensure that geologic-hazards investigations are performed for the safe siting of all new schools and critical public facilities.

- Continue assisting local governments with geoscience information and with guidance in planning and land-use in order to reduce risks from earthquakes and other geologic hazards (see p. 27).

- Support ongoing efforts by the University of Utah Seismograph Stations and the U.S. Geological Survey in developing urban strong-motion monitoring and a real-time earthquake information system in the greater Wasatch Front Area as part of an Advanced National Seismic System (see p. 37).

- Ensure that design professionals and building officials are kept current on relevant geoscience information.

- Advocate the disclosure of known geologic hazards in real-estate transactions so that homebuyers, prior to purchase, are appropriately informed of the risk they are assuming.

OTHER STRATEGIC OBJECTIVES

Since 1995 when the Commission created *A Strategic Plan for Earthquake Safety in Utah*, 27 (or three-fourths) of its 35 strategic objectives have either been successfully met or are being addressed in an ongoing way. Others not yet mentioned in this report and remaining to be addressed are the following:

2.2 — *Develop effective exercise and training programs for hospitals*
2.3 — *Enhance communication capabilities for emergency responders*
3.5 — *Mitigate nonstructural hazards in government-owned buildings*
3.7 — *Improve safety and operational ability of older hospital buildings*
3.9 — *Improve the seismic safety of older homes*
3.10 — *Improve safety of mobile homes*
3.11 — *Prevent loss of historic buildings*

Strategies 2.2 and 3.7 (hospitals) need the active participation and commitment of all the state's hospitals, for-profit and not-for-profit alike. Thankfully, some major health-care providers are already taking proactive measures. Hospitals occupy a unique position in any seismic mitigation scheme because they must remain operational in order to deal with casualties; no one else can fill that role. If hospitals cannot survive, casualties will be compounded.

With the implementation of *Project Impact* in Salt Lake City, and also with preparations for the 2002 Winter Olympics, communication capabilities for emergency responders (2.3) are being progressively enhanced—at least in the Salt Lake Valley. Communication capabilities for emergency response in other parts of Utah still need to be improved, and the Commission will use its influence to motivate needed actions.

The remaining strategies (3.5, 3.9, 3.10, and 3.11) will require more aggressive awareness and education, the commitment and involvement of communities and zoning agencies, and relevant legislation. Again, the Commission will use its influence to advocate needed improvement in these areas.

Mitigating the effects of earthquakes is a complex task. The effort begins with awareness, but has to be sustained with education, training, technical investigations, and a long-term commitment to risk reduction and preparedness. The Commission exists to help meet these challenges and will continue to do so.

APPENDIX A

THE STANDING COMMITTEES OF THE USSC, DECEMBER 2000

Awareness and Education Standing Committee
(incorporating an earlier separate committee on Emergency Management)

Robert D. Carey
Committee Chair
Utah Division of Comprehensive Emergency Management

Jan Gibbons
Davis School District

Andrew Glad
Sandy City Fire Department

Deborah H. Kim
University of Utah Medical Center

Brian Law
Davis County Emergency Services

Pat Lewis
State Farm Insurance Company

Ed O'Sullivan
Quake Pro

Tricia Porter
Provo City

Bruce A. Spiegel
Utah Division of Risk Management

Michael W. Stever
SLC Dept. of Mgmt Services

Valdee Wiltsey
Utah Office of Education

Former Committee Members During July 1996-June 2000
(including former members of Emergency Management Standing Committee)

Ann M. Becker, 1997-2000
URS Corporation

M. Lee Allison, 1996-1999
Utah Geological Survey

Cathy Bledsoe, 1996-1999
Utah State PTA Emergency Preparedness Committee

Jennifer Brown, 1999-2000
State Farm Insurance Company

Bob Halloran,1998-1999
Salt Lake County Fire, Emergency Services Bureau

Pat Iannone, 1996-2000
Utah Association of Realtors

Judy Johnson, 1998-1999
State Farm Insurance Companies

Gary Madsen, 1996-2000
Department of Sociology, Utah State University

Karen Mayne, 1996-1999
Provo City Police Department

Robert Nielson, 1998-1999
Mountain Fuel Supply Company

Deedee O'Brien, 1996-1999
Utah Geological Survey Board

Kathy Ochsenbein,1998-1999
Roy Junior High School

Patrick Reese, 1998-1999
Church of Jesus Christ of Latter-Day Saints

Alan D. Rindlisbacher, 1998-1999
Layton Construction Company

Paul Wanlass, 1996-2000
Salt Lake County Water Conservancy District

Engineering and Architecture Standing Committee

Barry H. Welliver
Committee Chair
Structural Engineers Association of Utah

Max A. Gregersen
CEntry Contractors & Engineers, Inc.

Thair Blackburn
Blackburn Architects

Parry Brown
Reaveley Engineers & Associates, Inc.

Ron Dunn
Dunn Associates, Inc.

Carl Eriksson
West Jordan Development Services

Roger Evans
Salt Lake City Corp.

Matthias Mueller
Utah Div. of Facilities Const. and Mgmt.

Barry Smith
Hart, Fisher, Smith & Associates

Former Committee Members During July 1996-June2000

James S. Bailey, 1996-2000
Allen & Bailey Engineers

Earle Eppich, 1996-1998
Reaveley Engineers & Associates, Inc.

William Juszcak, 1996-1998
Utah Division of Facilities Construction Management

Geoscience Standing Committee

Gary E. Christenson
Committee Chair
Utah Geological Survey

Walter J. Arabasz
University of Utah Seismograph Stations

Jon E. Bischoff
Utah Department of Transportation

Ronald L. Bruhn
University of Utah

Marvin W. Halling
Utah State University

Jeffrey R. Keaton
AMEC Earth & Environmental

Matthew Mabey
Brigham Young University

William R. Lund
Utah Geological Survey

James C. Pechmann
University of Utah Seismograph Stations

Joergen Pilz
AMEC Earth and Environmental

Kyle M. Rollins
Brigham Young University

James Wells
Utah Division of Water Rights, Dam Safety

T. Leslie Youd
Brigham Young University

Intergovernmental Relations Standing Committee
(assignment of Committee Chair pending)

Jay Aguilar
Bear River Association of Government

Walter J. Arabasz
University of Utah Seismograph Stations

Mark Bedel
Governor's Office of Planning & Budget

Kenneth H. Bullock
Utah League of Cities And Towns

Robert D. Carey
Utah Div. of Comprehensive Emergency Mgmt.

Diane Conrad
Salt Lake Olympic Organizing Committee

Jerry Grover
Mountainland Association of Governments

Prescott Muir
Prescott Muir Architects

David Owens
Five County Association of Governments

Carol Page
Wasatch Front Regional Council

Suzanne Winters
State Science Advisor

Lifelines and Infrastructure Standing Committee

David Nazare
Committee Chair
Utah Department of Transportation

Steven F. Bartlett
University of Utah

Robert D. Carey
Utah Div. of Comprehensive Emergency Mgmt.

Carl H. Carpenter
(Ground-Water Consultant)

Peter W. McDonough
PRIDE Engineering

Joergen Pilz
AMEC Earth and Environmental

Paul Wanless
Salt Lake County Conservancy District

Former Committee Members During July 1996-June 2000

James C. Golden, 1996-1999
Utah Dept. of Transportation

Guidelines Advisory Committee on Local Government Needs*

*Established in 1999 to advise the Commission's Geoscience Standing Committee and the Utah Geological Survey on local government needs for geoscience information to reduce risks from earthquakes and other geologic hazards.

Gary E. Christenson
Committee Chair
Utah Geological Survey

Carl Eriksson
Committee Advisor
West Jordan Development Services

Craig Barker
Weber County Planning

Darlene Batatian
Salt Lake County Planning

Jon Bischoff
Utah Department of Transportation

Ronald Bruhn
University of Utah

Scott Carter
Layton City Development Services

Andrew Jackson
Mountainlands Association of Governments

Jeffrey R. Keaton
AMEC Earth and Environmental

William R. Lund
Utah Geological Survey

Lane Nielson
Wasatch Front Regional Council

APPENDIX B

Enrolled Copy **H.B. 200**

UTAH SEISMIC SAFETY COMMISSION ACT AMENDMENTS

2000 GENERAL SESSION

STATE OF UTAH

Sponsor: Don E. Bush

AN ACT RELATING TO BOARDS AND COMMISSIONS; MODIFYING THE MEMBERSHIP OF THE UTAH SEISMIC SAFETY COMMISSION; ESTABLISHING FUNDING PARAMETERS; AND MAKING TECHNICAL CORRECTIONS.

This act affects sections of Utah Code Annotated 1953 as follows:

AMENDS:

63C-6-101, as last amended by Chapter 270, Laws of Utah 1999

63C-6-102, as enacted by Chapter 136, Laws of Utah 1994

63C-6-104, as enacted by Chapter 136, Laws of Utah 1994

Be it enacted by the Legislature of the state of Utah:

Section 1. Section **63C-6-101** is amended to read:

63C-6-101. Creation of commission -- Membership -- Appointment -- Vacancies.

(1) There is created the Utah Seismic Safety Commission consisting of [~~13~~] 15 members, designated as follows:

[~~(a) the commissioner of the Department of Public Safety;~~

~~(b)~~] (a) the director of the Division of Comprehensive Emergency Management or his designee;

[~~(c)~~] (b) the director of the Utah Geological Survey or his designee;

[~~(d)~~] (c) the director of the University of Utah Seismograph Stations or his designee;

[~~(e)~~] (d) the executive director of the Utah League of Cities and Towns or his designee;

[~~(f)~~] (e) a representative from the Structural Engineers Association of Utah biannually selected by [~~the~~] its membership;

[~~(g)~~] (f) the director of the Division of Facilities and Construction Management or his designee;

[~~(h)~~] (g) the executive director of the Department of Transportation or his designee;

[~~(i)~~] (h) the State Planning Coordinator or his designee;

[~~(j)~~] (i) a representative from the American Institute of Architects, Utah Section;

[~~(k)~~] (j) a representative from the American Society of Civil Engineers, Utah Section;

[~~(l)~~] (k) a member of the House of Representatives appointed biannually by the speaker of the House; [~~and~~]

[~~(m)~~] (l) a member of the Senate appointed biannually by the president of the Senate[~~.~~];

(m) the commissioner of the Department of Insurance or his designee;

(n) a representative from the Association of Contingency Planners, Utah Chapter, biannually selected by its membership; and

(o) a representative from the American Public Works Association, Utah Chapter, biannually selected by its membership.

(2) The commission shall annually select one of its members to serve as chair of the commission.

(3) When a vacancy occurs in the membership for any reason, the replacement shall be appointed for the unexpired term.

Section 2. Section **63C-6-102** is amended to read:

63C-6-102. Meetings -- Duties -- Committees.

(1) The commission shall meet at the call of the chair, but not less than once each quarter.

(2) The commission shall:

(a) review earthquake-related hazards and risks to the state of Utah and its inhabitants;

(b) prepare recommendations to identify and mitigate these hazards and risks;

(c) prioritize recommendations and present them to state and local government or other appropriate entities for adoption as policy or loss reduction strategies;

(d) act as a source of information for individuals and groups concerned with earthquake safety and as a promoter of earthquake loss reduction measures;

(e) prepare a strategic seismic planning document to be presented to the State and Local Interim Committee before the 1995 annual general session of the Legislature; and

(f) periodically update the planning document and monitor progress toward achieving the goal of loss reduction.

(3) The commission may:

(a) divide into or create subcommittees as it determines necessary to carry out its duties under this section[.]; and

(b) accept contributions from other private or public sources and seek grants or funding from the federal government for uses relating to seismic safety.

Section 3. Section **63C-6-104** is amended to read:

63C-6-104. Staffing and appropriated funds.

(1) Staff support to the commission shall be provided by the Division of Comprehensive Emergency Management and the Utah Geological Survey.

(2) Monies not expended by the Utah Seismic Safety Commission during a fiscal year are nonlapsing except that any balance of General Fund monies greater than $10,000 lapses to the General Fund.

APPENDIX C

STRATEGIC PLAN'S OBJECTIVES AND STRATEGIES

Objective 1: Increase earthquake awareness and education

Strategies
- 1.1 Inform citizens about earthquake hazards and risks.
- 1.2 Incorporate earthquake education in school curricula.
- 1.3 Disclose geologic hazards in real estate transactions.

Objective 2: Improve emergency response and recovery

Strategies
- 2.1 Establish Community Emergency Response Teams (CERTs) statewide.
- 2.2 Develop effective exercise and training programs for hospitals.
- 2.3 Enhance communication capabilities for emergency responders.
- 2.4 Enhance the integrated emergency management system statewide.

Objective 3: Improve the seismic safety of buildings and infrastructure

Strategies
- 3.1 Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.
- 3.2 Enforce the state amendment to the Uniform Building Code which requires building owners to install roof anchors and parapet bracing when reroofing their buildings.
- 3.3 Improve the post-earthquake operational status of essential service buildings.
- 3.4 Reduce structural hazards of government-owned buildings.
- 3.5 Mitigate nonstructural hazards in government-owned and -leased buildings.
- 3.6 Improve safety of older public school buildings.
- 3.7 Improve safety and operational ability of older hospital buildings.
- 3.8 Improve safety of older high-occupancy buildings (250 persons or more) to be structurally competent enough to withstand moderate to large earthquakes.
- 3.9 Improve the seismic safety of older homes.
- 3.10 Improve safety of mobile homes.
- 3.11 Prevent loss of historic buildings.
- 3.12 Improve lifelines survivability in the event of an earthquake.
- 3.13 Improve earthquake performance of water and waste-water systems.

Objective 4: Improve essential geoscience information

Strategies

- 4.1 Reduce earthquake losses by mapping and identifying geologic hazards.
- 4.2 Perform geologic-hazards investigations for critical public facilities.
- 4.3 Make land use compatible, through local government ordinances, with known hazards.
- 4.4 Ensure design professionals and building official are kept current on relevant geoscience information.
- 4.5 Determine appropriate seismic criteria and procedures for evaluating performance of existing dams.
- 4.6 Reduce earthquake-induced liquefaction risk to highway structures.
- 4.7 Determine appropriate seismic design coefficients for highway bridges.
- 4.8 Develop incrementally a strong-motion program.
- 4.9 Develop a statewide, real-time earthquake monitoring system.
- 4.10 Monitor faults using Global Positioning System (GPS) measurements.

Objective 5: Assess earthquake risk

Strategies

- 5.1 Update estimates of direct losses expectable from earthquakes.
- 5.2 Evaluate the indirect losses associated with earthquakes.
- 5.3 Conduct lifeline collocation vulnerability studies.

APPENDIX D

Prepared Schools Certification

Level I

____ Our alarms, which may include fire protection systems and possibly strobe lights, are maintained and in working order and are in compliance with the local Fire Marshal's inspection. *(R277-400-7 B (4) & R277-400-8 A)*

____ We hold fire drills once a month if we are an elementary school and every other month if we are a secondary school. *(R277-400-7 B) (Uniform Fire Code 1303.3.3.2.1) (Utah Fire Marshal's Rules and Regulations) (R710-4-3.9.2)*

____ We hold one other type of drill yearly i.e., earthquake drill, violent intruder, etc. *(R277-400-7 C)*

____ We hold an Emergency Preparedness Week prior to April 30 (preferably during the month of April) of each school year. *(R277-400-7 E)*

____ We have a first aid kit in the main office that is currently stocked and portable. *(Utah Administrative Code Rule R392-200-7-A-1)*

____ We have a record of all students on medication and/or receiving special health services. *(Utah Administrative Code 53A-11-601) (Utah Administrative Code Rule R392-700-7.3 & 4) (Guidelines for Children with Special Health Care Needs, p.23)*

____ We have provisions for back up medication for the special needs of students and staff in our school.

____ We have assessed and recorded the abilities of our staff i.e. C.P.R., C.E.R.T., First Aid, etc.

____ We have three people currently certified in first aid and C.P.R. *(Utah Administrative Code Rule R392-200-7 A) (Utah Administrative Code Rule R392-200-7-A-1)*

____ We have an active Safety Committee which includes an administrator, teacher, custodian, and a member of the P.T.A. *(R277-400-3 B & R277-400-4 A & B)*

____ We have a policy and procedure for contacting parents and releasing students following a disaster. *(R277-400-6 A & B)*

____ We have emergency procedures in place for evacuating students with special health care needs i.e., wheelchair bound, and those who use assisted walking devices. *(Guidelines for Children with Special Health Care Needs)*

Nonstructural hazards:

____ We hold an annual nonstructural hazard hunt in all classrooms.
____ We have defined our nonstructural hazards in easy-fix, low-cost, and long-term categories.
____ We have taken care of all easy-fix hazards.

Please note: The Utah State Board of Education Policies and Procedures have been listed in the parentheses following each item, unless otherwise noted.

Level II (includes everything in level I as well as the following):

____ We have invited our local police and fire departments to be a part of our safety committee. *(R277-400-3 B)*

____ We have the necessary equipment for special-need students and staff, such as backup power for a ventilator. *(Guidelines for Children with Special Health Care Needs)*

____ We have expanded our fire drills to include obstacles that will add confusion to the evacuation i.e., blocked doors, missing persons, etc.

____ We have a backpack (or container) in every classroom with the minimum of supplies suggested by the Schools Subcommittee for the Utah Seismic Safety Commission needed for a disaster. This container is checked and updated annually.

____ We have 10% or four persons, whichever is greater, of our full-time staff currently certified in CPR and first aid. Schools with less than 10 people on staff will be given special considerations.

____ We have a five-year plan to reduce long-term nonstructural hazards. We have addressed all low-cost nonstructural hazards.

____ We have completed a Hazard and Risk Assessment.

____ We have an all-hazards emergency response plan. Examples of school plans are available from the Division of Comprehensive Emergency Management. *(R277-400-4)*

____ We inform parents, students, and staff of their part in the plan annually. *(R277-400-5)*

____ We train and educate students and staff on emergency response procedures for the specific hazards compiled in our Hazard and Risk Assessment. *(R277-400-6)*

____ We hold annual drills which include evacuation of all persons in the building, accountability of the entire staff and student body, and release of students in accordance with the school plan. Each drill has been evaluated by our Safety Committee. *(R277-400-6 B) (Uniform Fire Code 1303.3.3.2.2)*

____ We have tested our plan in a tabletop exercise and have made the appropriate modifications to the plan.

____ We have submitted our school emergency response plan for review to the *Utah Seismic Safety Commission, c/o Bob Carey, 1110 State Office Building, SLC, UT 84114.*

What should be included in the School Emergency Response Plan:

____ Our plan includes procedures to respond to all the hazards compiled in the Hazard and Risk Assessment, including violence.

____ Our plan includes all policies and procedures listed in Level 1.

____ Our plan includes procedures for contacting school district personnel, the school nurse, and parents.

____ Our plan includes what students, teachers, staff, and others in the building should do during and immediately following an earthquake. (Some schools do not have earthquakes, but when students travel to an earthquake prone area they need to know what to do.)

____ Our plan includes a policy and procedure for sheltering the students for 24 hours.

____ Our plan has been disseminated to the district office, and the local fire and police departments for their information.

Web Page Resources:

Home page for School Subcommittee of the Utah Seismic Safety Council:
http://www.davis.k12.ut.us/emrprep/schsub/schsub.htm

Contents of backpack or bucket:
http://www.davis.k12.ut.us/emrprep/schsub/backpack.htm

How to evacuate a building:
http://www.davis.k12.ut.us/emrprep/schsub/bldevac.htm

Drill Evaluation:
http://www.davis.k12.ut.us/emrprep/schsub/drilleva.htm

Earthquake drills:
http://www.davis.k12.ut.us/emrprep/schsub/eqdrill.htm

Earthquake drill evaluation:
http://www.davis.k12.ut.us/emrprep/schsub/eqdrlevl.htm

Evacuation of School Grounds:
http://www.davis.k12.ut.us/emrprep/schsub/evacgrds.htm

Fire Alarm Log:
http://www.davis.k12.ut.us/emrprep/schsub/firelog.htm

Non-structural Hazard Hunt:
http://www.davis.k12.ut.us/emrprep/schsub/hazhunt.htm

Medical Release Form:
http://www.davis.k12.ut.us/emrprep/schsub/medrelse.htm

Missing Persons Form:
http://www.davis.k12.ut.us/emrprep/schsub/misngfrm.htm

Parent Release Form (who can I release the students to?):
http://www.davis.k12.ut.us/emrprep/schsub/parelse.htm

How to release students to parents:
http://www.davis.k12.ut.us/emrprep/schsub/re2prnts.htm

Student Release Form (actual sign out form):
http://www.davis.k12.ut.us/emrprep/schsub/srelfrm.htm

Workshop information flyer:
http://www.davis.k12.ut.us/emrprep/schsub/wkspflr.htm

APPENDIX E

SURVEY OF SEISMIC SAFETY INITIATIVES, 2000

The Commission, seeking to add to the insights gained in the 1996 survey of businesses and governments, polled those same audiences to learn more about their state of seismic safety awareness. Two separate questionnaires were sent: one to business organizations (appendix F) and one to cities and counties (appendix G).

The businesses were selected on the basis of their membership in or support of the Association of Contingency Planners. The presumption was that such businesses would be the most likely to have policies and procedures in place to deal with catastrophes and would also be the most likely to share their insights. A total of 52 businesses received the questionnaire; 18, or 35 percent, responded. All the businesses are located within UBC Seismic Zone 3.

Each questionnaire was quantified to a maximum score of 80 points, with total scores categorized into one of four types: Highly Aggressive (61-80 points), Aggressive (41-60), Attentive (21-40), and Minimal (up to 20).

Organizations that participated in the survey included:

Autolive ASP	6,000 employees
Bear River Mutual	52 employees
Bergen Brunswig	70 employees
Brigham Young Univ	3,500 employees
Deseret First C U	110 employees
First Security	2,000 employees
Flying J	1,000 employees
Franklin Quest	2,500 employees
IHC	22,000 employees
Novell	1,500 employees
Questar	1,800 employees
St. Mark's Hospital	1,200 employees
SPS Technologies	200 employees
Thiokol Corporation	3,400 employees
Utah Power	2,800 employees
Utah Valley State	2,000 employees
Workers Compensation	335 employees
Zions Bancorporation	6,000 employees

The other questionnaire went to all 29 counties (12 responses for 41 percent) and all cities in Utah with a population of more than 1,000 (31 of the 112 cities, or 28 percent, responded).

Counties that responded included:

Beaver	Zone 2B
Box Elder	Zone 2B/3
Cache	Zone 3
Duchesne	Zone 1/2B
Emery	Zone1/2B
Grand	Zone 1
Salt Lake	Zone 3
San Juan	Zone 1/2B
Sanpete	Zone 2B/3
Utah	Zone 2B/3
Wayne	Zone 1/2B
Weber	Zone 3

Cities that responded included:

Beaver	Zone 2B
Blanding	Zone 1
Enoch	Zone 2B
Enterprise	Zone 2B
Gunnison	Zone 3
Heber City	Zone 3
LaVerkin	Zone 2B
Logan	Zone 3
Manti	Zone 3
Midway	Zone 3
Monticello	Zone 2B
Naples	Zone 1
North Ogden	Zone 3
Ogden	Zone 3
Orangeville	Zone 2B
Panguitch	Zone 2B
Park City	Zone 3
Payson	Zone 3
Perry	Zone 3
Plain City	Zone 3
Providence	Zone 3
Provo	Zone 3

Richmond	Zone 3
Salt Lake City	Zone 3
Smithfield	Zone 3
South Ogden	Zone 3
Spanish Fork	Zone 3
Syracuse	Zone 3
Tremonton	Zone 3
Vernal	Zone 1
Wendover	Zone 2B

The organizations fell into the following Initiative Ranking categories (percentages are rounded to the next whole number, so some categories may not total exactly 100 percent): Highly Aggressive (10 of 18, or 55 percent), Aggressive (4 of 18, or 22 percent), Attentive (3 of 18, or 17 percent), Minimal (1 of 18, or 6 percent).

Although three of the state's largest employers rank as Highly Aggressive, 40 percent of the organizations in that category have fewer than 400 employees, indicating that the size of the organization is not a factor in whether it focuses on seismic safety issues.

The responses:

- **Question 1** (5 points) on policies and procedures in place: All organizations had some form of policies and procedures in place for disasters; 78 percent (14 of 18) addressed the issue of seismic safety specifically in their plans.

- **Question 2** (5 points) on whether seismic safety issues were discussed by employee councils or management teams: Four (22 percent) said they had never discussed these issues in any forum; 2 (11 percent) were making efforts to establish some way to bring these issues to the employees on a consistent basis; and 12 (67 percent) had discussed the issues with employees on at least an annual basis.

- **Question 3** (10 points) on the organization's own rating (from 1 — unaware, to 10 — fully informed) of its knowledge of earthquake risk factors: 72 percent (13 of 18) rated themselves as more than adequately informed.

- **Question 4** (5 points) on whether the organization was aware of training in earthquake safety for its safety and security personnel: 78 percent (14 of 18) were aware of such training; and 56 percent (10 of 18) provided that type of training in-house and on a regular basis.

- **Question 5** (10 points) on whether earthquake-response training was provided on a regular basis for safety and security people: 33 percent (6 of 18) sent their personnel to annual training, and 33 percent (6 of 18) provided it in-house; 11 percent (2 of 18) provided some training on occasion, and another 17 percent (3 of 18) made such training available more often than annually.

- **Question 6** (10 points) on whether other personnel in the organization knew about special training, who received it, and how often: 56 percent (10 of 18) reported having some process in place to keep every one else in the organization, including upper management, informed on a regular basis as to who the seismic safety experts within the organization were.

- **Question 7** (5 points) on whether the organization had ever retrofitted or upgraded any of its physical structures to meet earthquake code: 61 percent (11 of 18) reported that they had made some effort in the past four years to upgrade or retrofit one or more of these. Slightly less than a quarter of the respondents (22 percent, or 4 of 18) said their structures were all new so upgrading or retrofitting was not an issue.

- **Question 8** (5 points) on whether there was a perception that some of the buildings needed to be upgraded or retrofitted: 56 percent (10 of 18) said they were aware of some needs; and 33 percent (6 of 18) said there was no need.

- **Question 9** (5 points) on whether the organization had given any priority to retrofitting or upgrading needs: 61 percent (11 or 18) said the question did not apply or did not respond; 22 percent gave their needs a high priority; and 17 percent gave them a low priority.

- **Question 10** (10 points) on frequency of the review process for policy and procedures: 83 percent (15 of 18) said they reviewed their disaster plans on at least an annual basis; 6 percent (1 of 18) did it on a quarterly basis; and 11 percent (2 of 18) did not have a review process.

- **Question 11** (10 points) on involvement of management in the review process: 44 percent (8 of 18) involved upper management; 44 percent (8 of 18) involved to the middle-management level; and 12 percent (2 of 18) had no process.

The counties and cities questionnaire also had a maximum of 80 points, though with different questions.

Only one county (8 percent of the total responding) ranks in the Highly Aggressive category (61-80 points), and it is in Seismic Zone 2B/3. In the Aggressive category are three counties (25 percent); two are in Zone 3 and one in Zone 2B/3. Four counties (33 percent) are in the Attentive category; one in Zone 3, two in Zone 1, and one in Zone 1/2B. The Minimal category contains the final four (33 percent); one is in Zone 1/2B, one in Zone 2B, and one in Zone 2B/3.

Because of the distribution of counties throughout the categories, the survey indicated that the Seismic Zone did not play a significant role in any county's Initiative Ranking.

The responses:

- **Question 1** (5 points) on ordinances, codes, or planning: 75 percent (9 of 12) listed the Uniform Building Code (UBC) 1997 version as their guideline; 58 percent (7 of 12) listed the UBC and local planning or initiatives; and 25 percent (3 of 12) listed no ordinances, codes, or planning for seismic safety.

- **Question 2** (10 points) on whether the county commission discussed seismic safety issues: 8 percent (1 of 12) said it was discussed annually; 17 percent (2 of 12) said it was occasionally discussed; and 75 percent (9 of 12) said it was never discussed.

- **Question 3** (5 points) on whether building permits had been modified or denied because of earthquake safety issues in the last four years: 42 percent (5 of 12) said it had happened; and 58 percent (7 of 12) said it had never happened.

- **Question 4** (10 points) on building inspector knowledge of earthquake hazard issues: 67 percent (8 of 12) ranked themselves 5 or higher on a 10-point scale (1 = no knowledge); and 33 percent (4 of 12) ranked themselves lower than 5.

- **Question 5** (5 points) on their knowledge of seismic safety training available for their building inspectors: 42 percent (5 of 12) knew of or participated in at least two methods of training; 25 percent (3 of 12) knew of a course; and 33 percent (4 of 12) had no knowledge of training available.

- **Question 6** (5 points) on the number of public/government buildings retrofitted or upgraded in the past four years: 92 percent (11 of 12) had no knowledge of or said no such work had been done; and 8 percent (1 of 12) said there had been at least one incidence of that occurring.

- **Question 7** (5 points) on knowledge of public/government buildings that were in need of retrofit or upgrade to meet seismic standards: 58 percent (7 of 12) had no knowledge of such a need or indicated that no need existed within their counties; and 42 percent (5 of 12) said their were aware of at least a few buildings that were in need.

- **Question 8** (10 points) on what priority ranking on a scale of 1 - 10 (1 = no priority) they would give the need for retrofit or upgrade: 17 percent (2 of 12) ranked the priority at 5 or higher; and 83 percent (10 of 12) put the priority at lower than 5.

- **Question 9** (5 points) on whether they thought building permits issued in the past four years were in compliance with existing codes (on a scale of 1 - 10, 1 = non-compliance): 75 percent (9 of 12) put themselves at a 5 or higher; and 25 percent (3 of 12) said they didn't know.

- **Question 10** (5 points) on instances where work had to be interrupted or was otherwise affected because of seismic safety issues: 8 percent (1 of 12) said it had happened at least once; 25 percent (3 of 12) said they didn't know if it had happened; and 67 percent (8 of 12) said it had never happened.

- **Question 11** (10 points) on whether there was a review process for seismic safety policies and procedures: 8 percent (1 of 12) had annual discussions; 25 percent (3 of 12) reviewed the policies at least occasionally; and 67 percent (8 of 12) either had no review process of didn't know of any.

- **Question 12** (10 points) on whether anyone in authority participated in the review process: 67 percent (8 of 12) said they either had no process, didn't know of a process, or reviewed the policies at the building inspector level; and 33 percent (4 of 12) said the process involved county officials or elected officials.

Of the cities that responded to the survey, 39 percent (12 of 31) had populations less than 2,500; 19 percent (6 of 31) had populations between 2,500 and 5,000; 16 percent (5 of 31) had populations of between 5,000 and 10,000; 13 percent (4 of 31) had populations of between 10,000 and 25,000; and 13 percent (4 of 31) had population of more than 25,000.

In addition, 65 percent (20 of 31) of the cities responding are in Zone 3; 26 percent (8 of 31) are in Zone 2B; and 9 percent (3 of 31) are in Zone 1. That correlates fairly well with the overall averages, which show that 71 percent (80 of 112) of all the cities in Utah that received the survey are in Zone 3; 24 percent of them (27 of 112) are in Zone 2B; and 4 percent (4 of 112) are in Zone 1.

Of the cities that responded, 26 percent (8 of 31) ranked as Highly Aggressive with Seismic Initiative scores of between 61 and 80. All but one of the cities are within Zone 3, and the other is within Zone 2B. One has a population of between 1,000 and 2,500; three have populations of between 5,000 and 10,000; two have populations of between 10,000 and 25,000; and two had populations of more than 25,000.

In the Aggressive category, with Seismic Initiative scores of between 41 and 60, were 26 percent (8 of 31) of the responding cities. Again, all but one are within Zone 3, and the other is within Zone 1. Two have populations of between 2,500 and 5,000; two, between 5,000 and 10,000; two, between 10,000 and 25,000; and two, more than 25,000.

Fewer cities, 19 percent (6 of 31) made up the Attentive category with Seismic Initiative scores of between 21 and 40. Two are in Zone 1; two in Zone 2B; and two in Zone 3. Four have populations of between 1,000 and 2,500; and two, between 2,500 and 5,000.

The Minimal category had 29 percent (9 of 31) with Seismic Initiative scores of 20 or lower. Five are in Zone 2B and four are in Zone 3. Eight have populations of between 1,000 and 2,500; and one, between 2,500 and 5,000.

The Seismic Initiative scores of the cities seem to be affected by their population. The cities that ranked lowest on the scale were among the smallest, but no city with a population of over 5,000 ranked less than Aggressive. All four of the largest cities scored in the Aggressive or Highly Aggressive category.

The responses (the questionnaire was the same as the one used for the counties):

- **Question 1** (5 points): 77 percent (24 of 31) relied on the UBC and/or other building codes (IBC, UCBC); 42 percent (13 of 31) relied on the UBC and some local initiatives; 16 percent (5 of 31) had no ordinances; and 6 percent (2 of 31) had only local initiatives to follow.

- **Question 2** (10 points): 58 percent (18 of 31) either didn't know or didn't have any reviews or discussions at the city level on seismic hazards; 26 percent (8 of 31) discussed the issue at least occasionally; 16 percent (5 of 31) discussed the issue on at least an annual basis.

- **Question 3** (5 points): 32 percent (10 of 31) had denied some permits in the past four years; 58 percent (18 of 31) did not; 10 percent (3 of 31) didn't know.

- **Question 4** (10 points): 45 percent (14 of 31) rated themselves at 5 or higher on a scale of 1 - 10 (1 = no knowledge); 42 percent (13 of 31) rated themselves at less than 5; 13 percent (4 of 31) didn't know.

- **Question 5** (5 points): 32 percent (10 of 31) detailed specific training programs they knew of or had participated in; 36 percent (11 of 31) said they knew of some training programs available; 32 percent (10 of 31) knew of no training available.

- **Question 6** (5 points) on the number of public/government buildings retrofitted or upgraded in the past four years: 71 percent (22 of 31) had no knowledge of or said no such work had been done; 29 percent (9 of 31) said there had been at least one incidence of that occurring.

- **Question 7** (5 points): 81 percent (25 of 31) said they knew of some public/government buildings that needed seismic upgrades or retrofitting; 19 percent (6 of 31) said they either didn't know of any or said there were none.

- **Question 8** (10 points): 29 percent (9 of 31) rated the priority for upgrading or retrofitting public/government buildings at 5 or higher on a scale of 1 - 10 (1 = no priority); 71 percent (22 of 31) put that priority at less than 5.

- **Question 9** (5 points): 68 percent (21 of 31) rated their compliance at 5 or higher on a scale of 1 - 10 (1 = non-compliant); 32 percent (10 of 31) said they either didn't know or were at 0 on the scale.

- **Question 10** (5 points): on instances where work had to be interrupted or was otherwise affected because of seismic safety issues: 23 percent (7 of 31) said it had happened at least once; 77 percent (24 of 31) said they didn't know if it had happened or said it had never happened.

- **Question 11** (10 points): 19 percent (6 of 31) have periodic review of seismic safety ordinances at the city level; 23 percent (7 of 31) have occasional reviews; 58 percent (18 of 31) have no review process or did not know of any.

- **Question 12** (10 points): 52 (16 of 31) percent said they didn't know who was involved in the review process or didn't have a review; 48 percent (15 of 31) were able to detail the people involved in the review process.

APPENDIX F

SURVEY QUESTIONNAIRE FOR BUSINESS ORGANIZATIONS

1. Please list or briefly describe the policies and procedures in your organization that relate to earthquake safety.

2. Since July 1, 1996, how many times were seismic safety policies and procedures formally discussed by your employee council or management team?

3. How would you rate your knowledge of earthquake risk factors, such as surface fault rupture, liquefaction, and ground shaking? Rate your knowledge on a scale of 1 (unaware) to 10 (fully knowledgeable).

4. What training is available to you or your safety and security people to help update/gain knowledge of earthquake risk factors?

5. Have you or any of your safety and security people been trained specifically in how to respond to earthquake emergencies? Please specify what training was received and when anyone last attended that training.

6. Who else in your organization, including upper management, knows who has special training or expertise in earthquake response? How is that information disseminated, and how often?

7. Has there ever been an effort to upgrade or retrofit your building(s) for earthquake safety? Please specify what was done.

8. In your opinion, are there structures your organization currently uses that are in need of seismic upgrades/retrofitting? Please specify what those needs are:

9. How would you prioritize each need listed in the previous question on a scale of 1 (no priority now) to 10 (immediate concern).

10. How often do you review your earthquake safety policies and procedures? Circle one:
Annually Quarterly Other *(specify)* Don't Know Does Not Apply

11. Who is involved in the review process? *(Please specify by title; if there is no review process, please indicate)*

12. How many employees does your organization have in Utah?

APPENDIX G

SURVEY QUESTIONNAIRE FOR CITIES AND COUNTIES

1. Please list or briefly describe ordinances, development codes, and planning in your city/county that relate to earthquake safety.

2. Since July 1, 1996, how many times were questions of earthquake safety formally discussed by the city council/county commission? Please describe.

3. Since July 1, 1996, were there occasions when seismic risk was a consideration in denying or modifying building/development/construction permits? Please briefly describe.

4. How would you rate the building inspectors in your jurisdiction as to their knowledge of earthquake risk factors, such as surface fault rupture, liquefaction, and ground shaking? Rate on a scale of 1 (unaware) to 10 (fully knowledgeable).

5. What training is available to your building inspectors to help them update/gain knowledge of earthquake risk factors?

6. Since July 1, 1996, how many public/government buildings in your area (excluding schools) have been upgraded or retrofitted for seismic safety?

7. Again excluding schools, and taking into consideration the earthquake hazard in your region, approximately what percentage of public/government buildings in your area are in need of seismic upgrades/retrofitting?

8. How would you prioritize that work on a scale of 1 (no priority now) to 10 (immediate concern).

9. Since July 1, 1996, have building/development/construction permits issued in your region been in compliance with your local seismic ordinances? Please rate on a scale of 1 (non-compliant) to 10 (fully compliant).

10. How many instances have there been in your region when building, development, and construction work were interrupted or otherwise affected because it was not in compliance with your local seismic safety ordinances?

11. How often do you review your seismic safety ordinances? Circle one:
Annually After Elections Other *(specify)* Don't Know Does Not Apply

12. Who is involved in the review process? *(Please specify by title; if there is no review process, please indicate)*